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(54) **SURGICAL INSTRUMENT HAVING A MULTIPLE RATE DIRECTIONAL SWITCHING MECHANISM**

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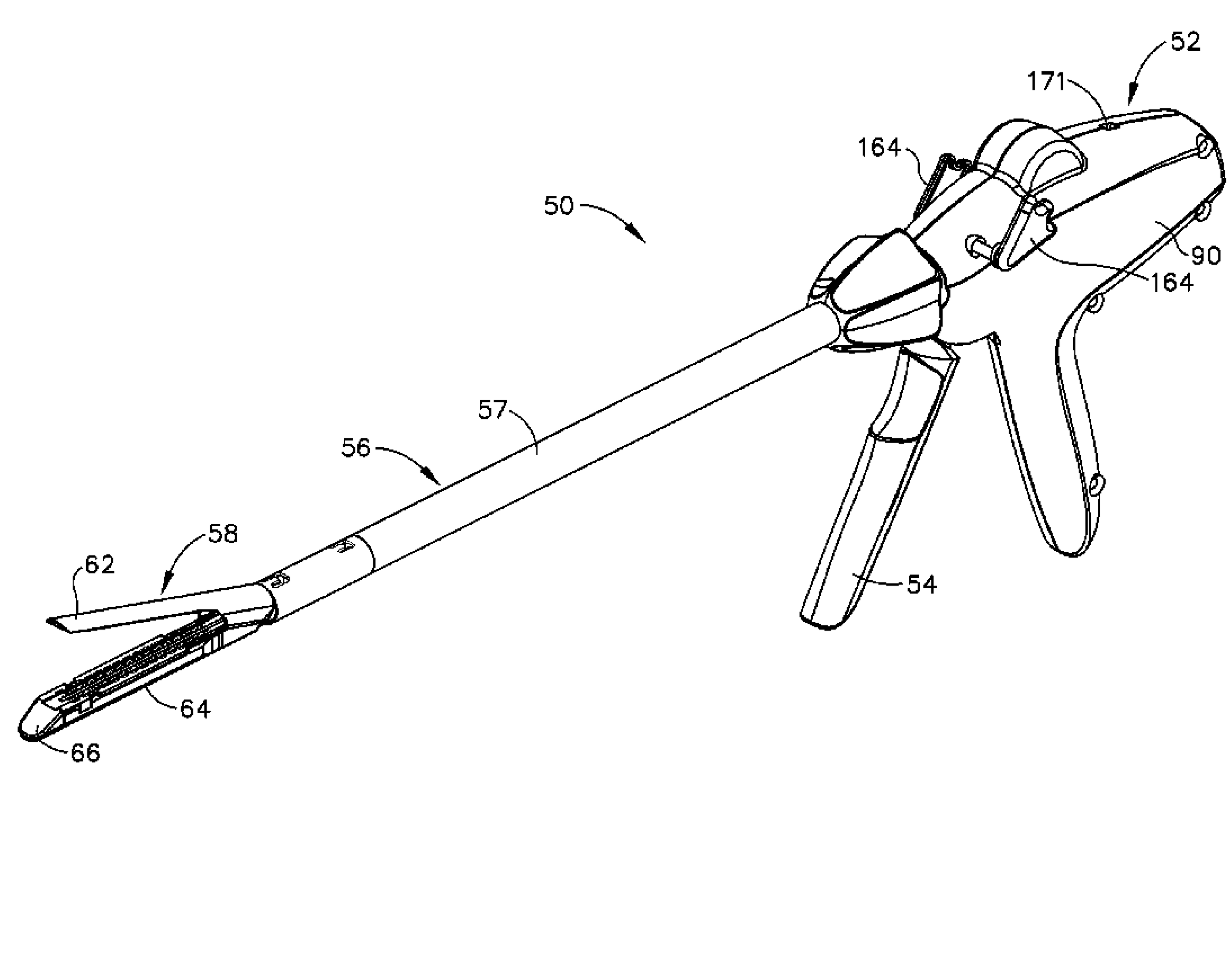
(57) **ABSTRACT**

A surgical instrument having a remotely controllable user interface, and a firing drive configured to generate a rotary firing motion upon a first actuation of the remotely controllable user interface and a rotary refraction motion upon an other actuation of remotely controllable user interface. The instrument is such that when the remotely controllable user interface operates a first drive member, the first actuation advances a cutting member a first distance, wherein, when the remotely controllable user interface operates a second drive member, the other actuation retracts the cutting member a second distance, and wherein the second distance is greater than the first distance.

1 Claim, 32 Drawing Sheets



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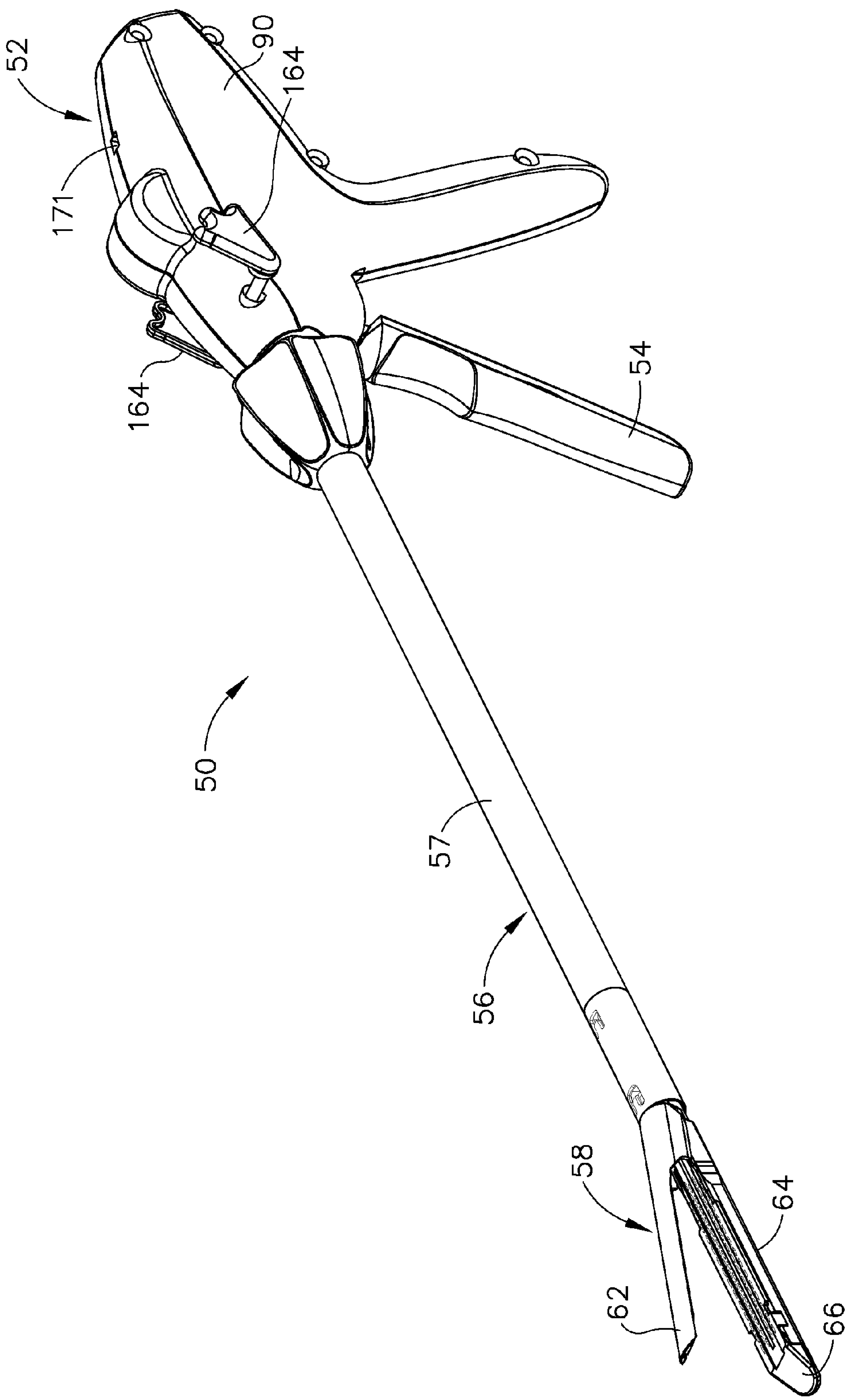

FIG. 1

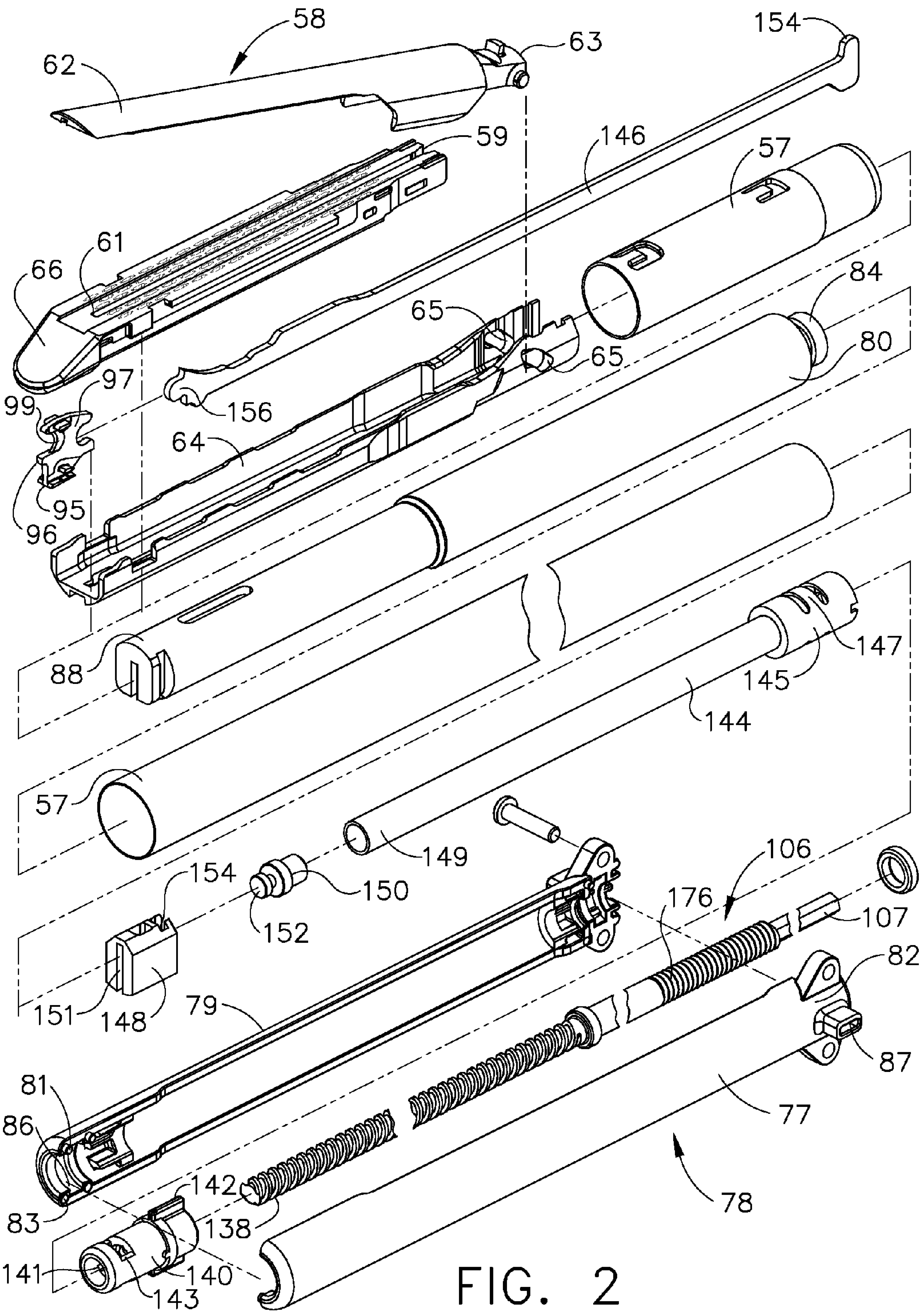
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FIG. 2

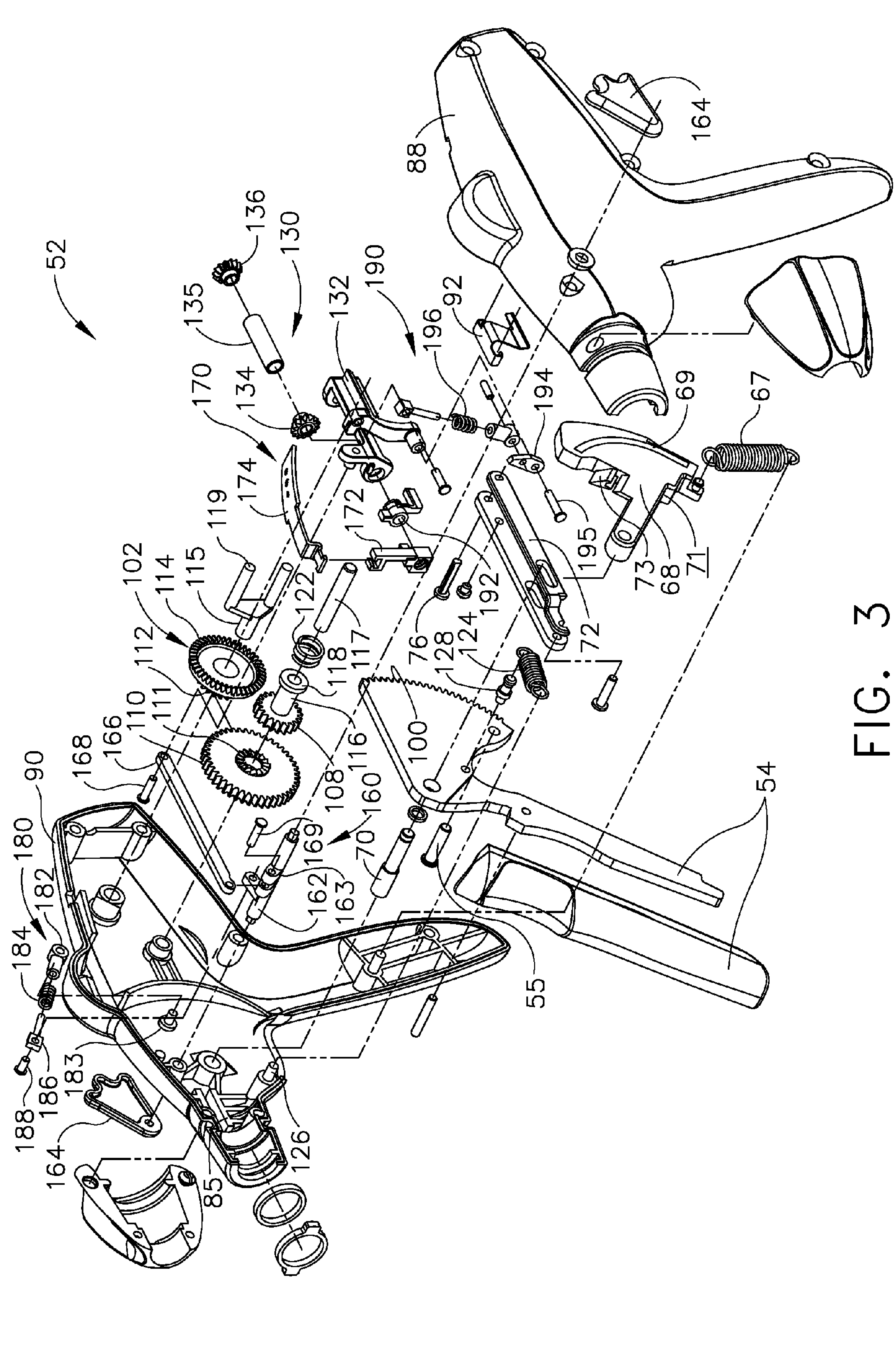
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FIG. 3

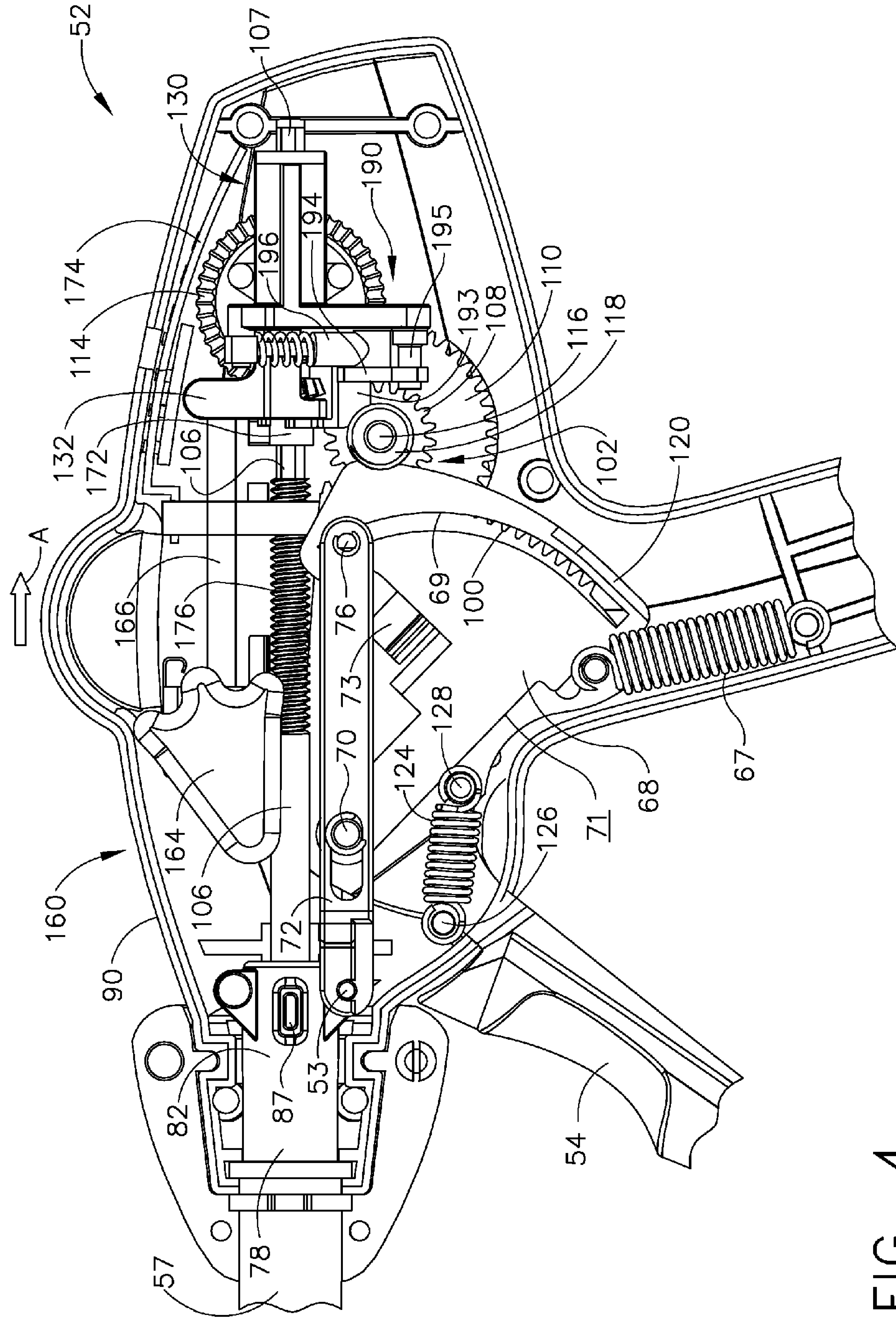
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FIG. 4

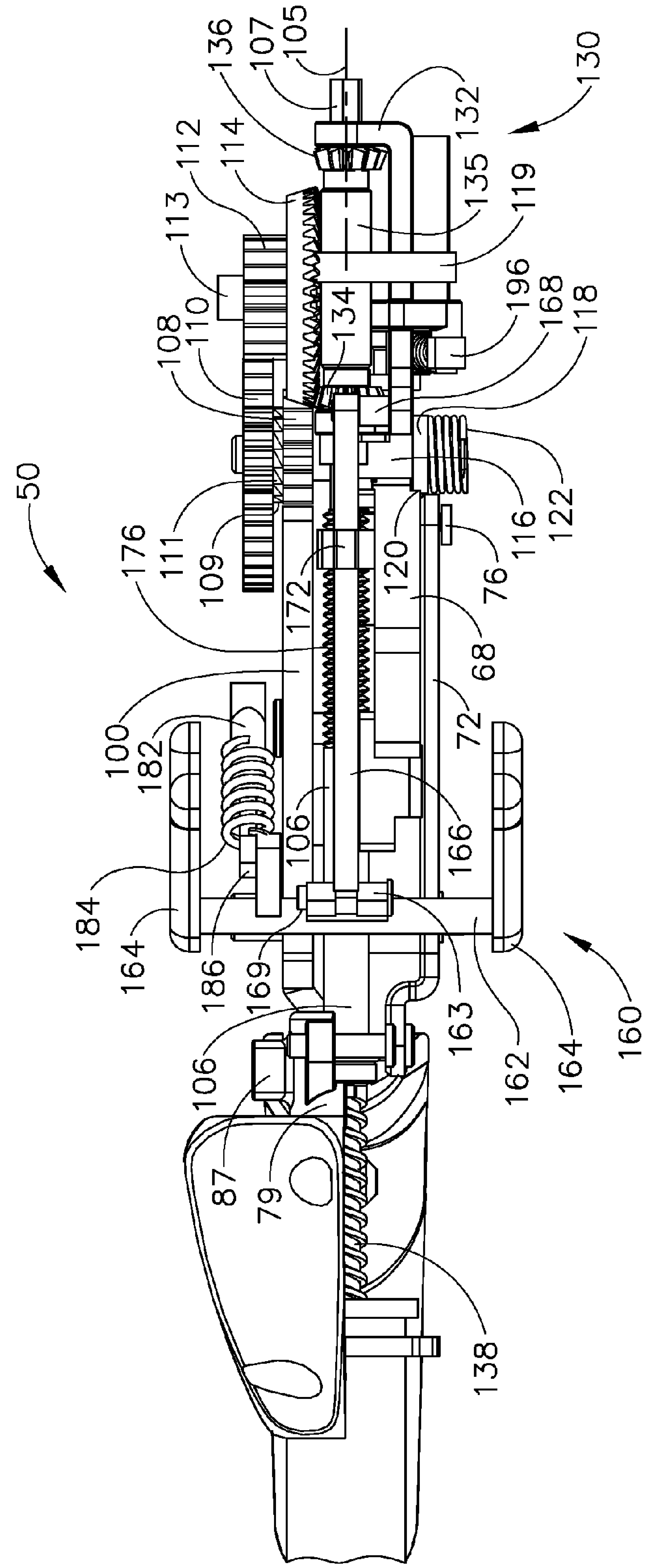
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FIG. 5

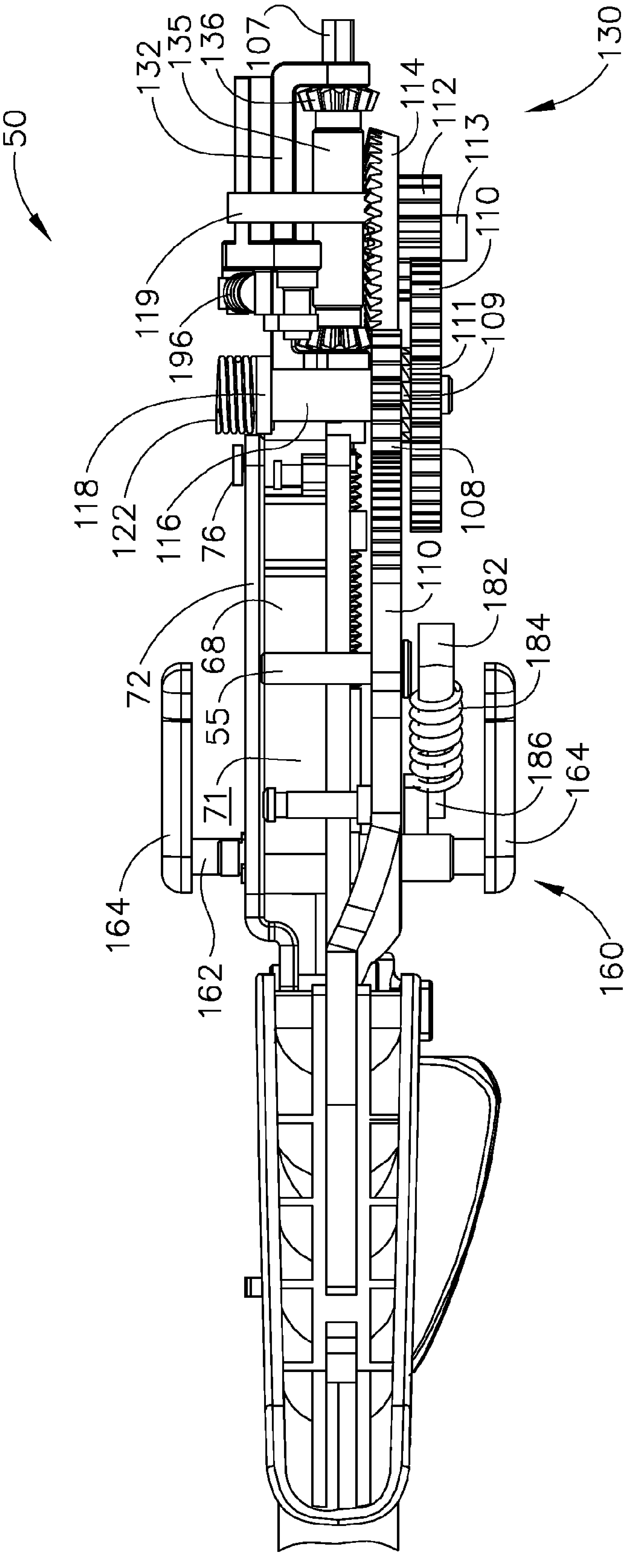
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FIG. 6

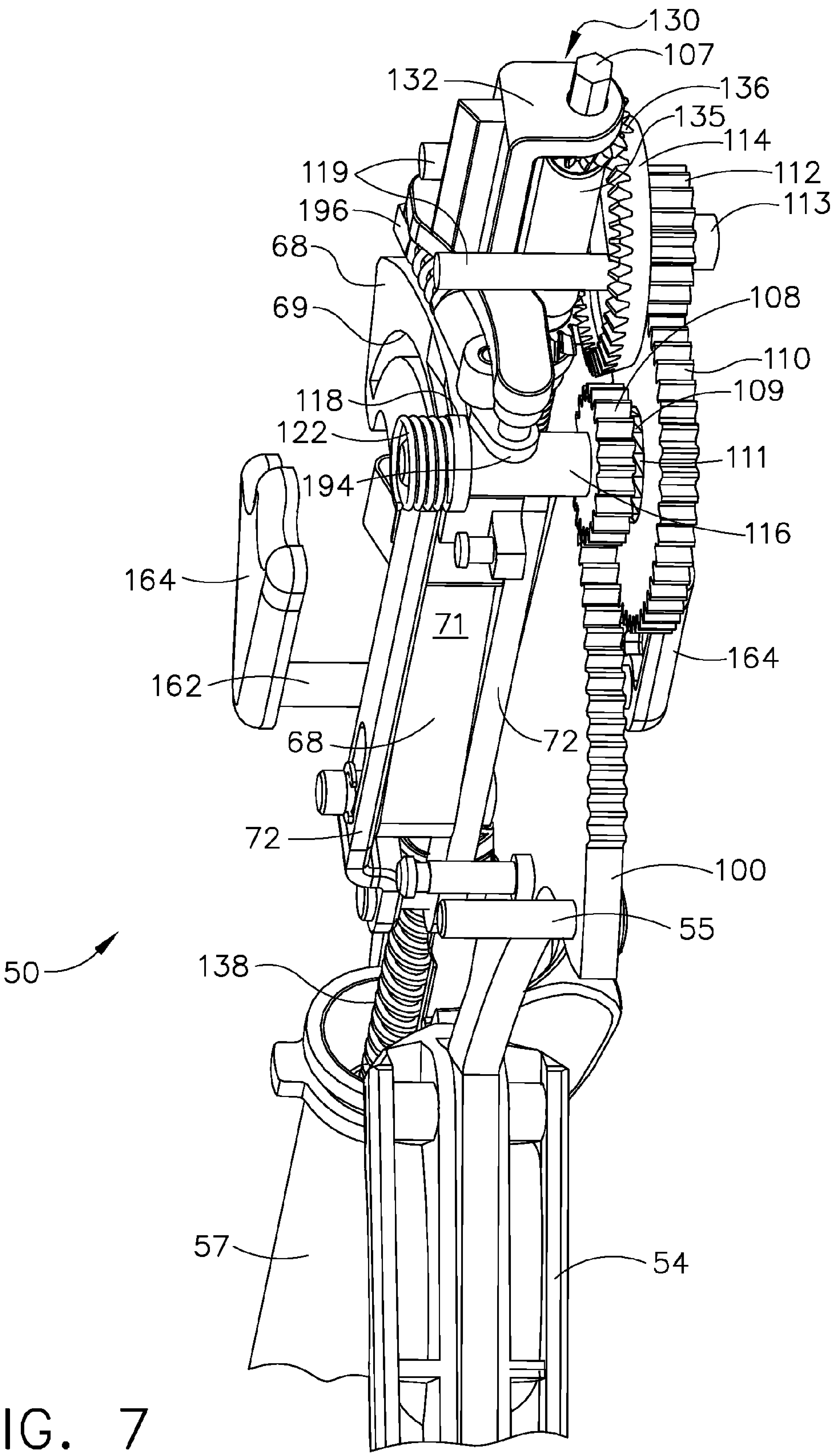
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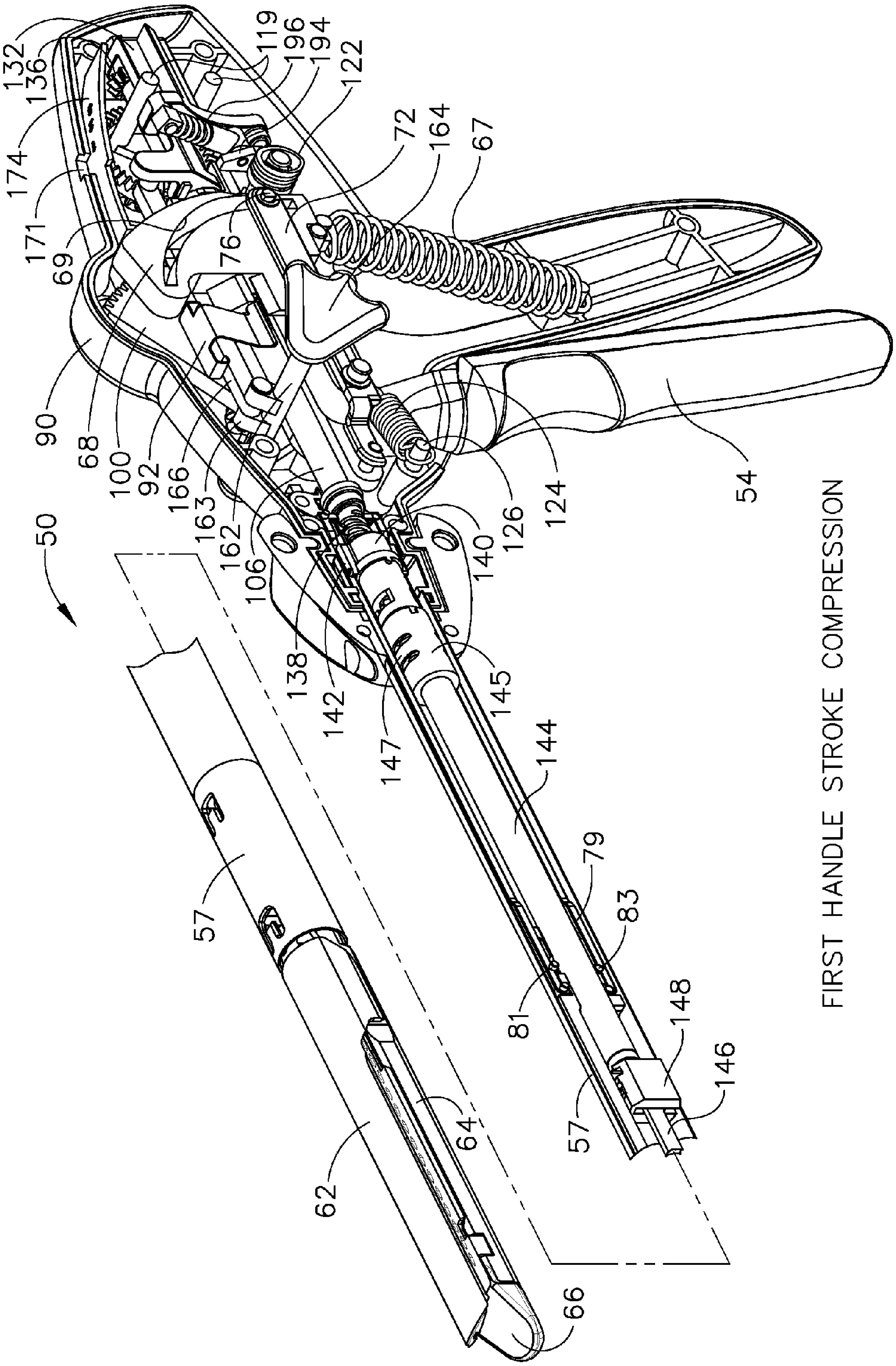
FIG. 7



FIRST HANDLE STROKE COMPRESSION

FIG. 8

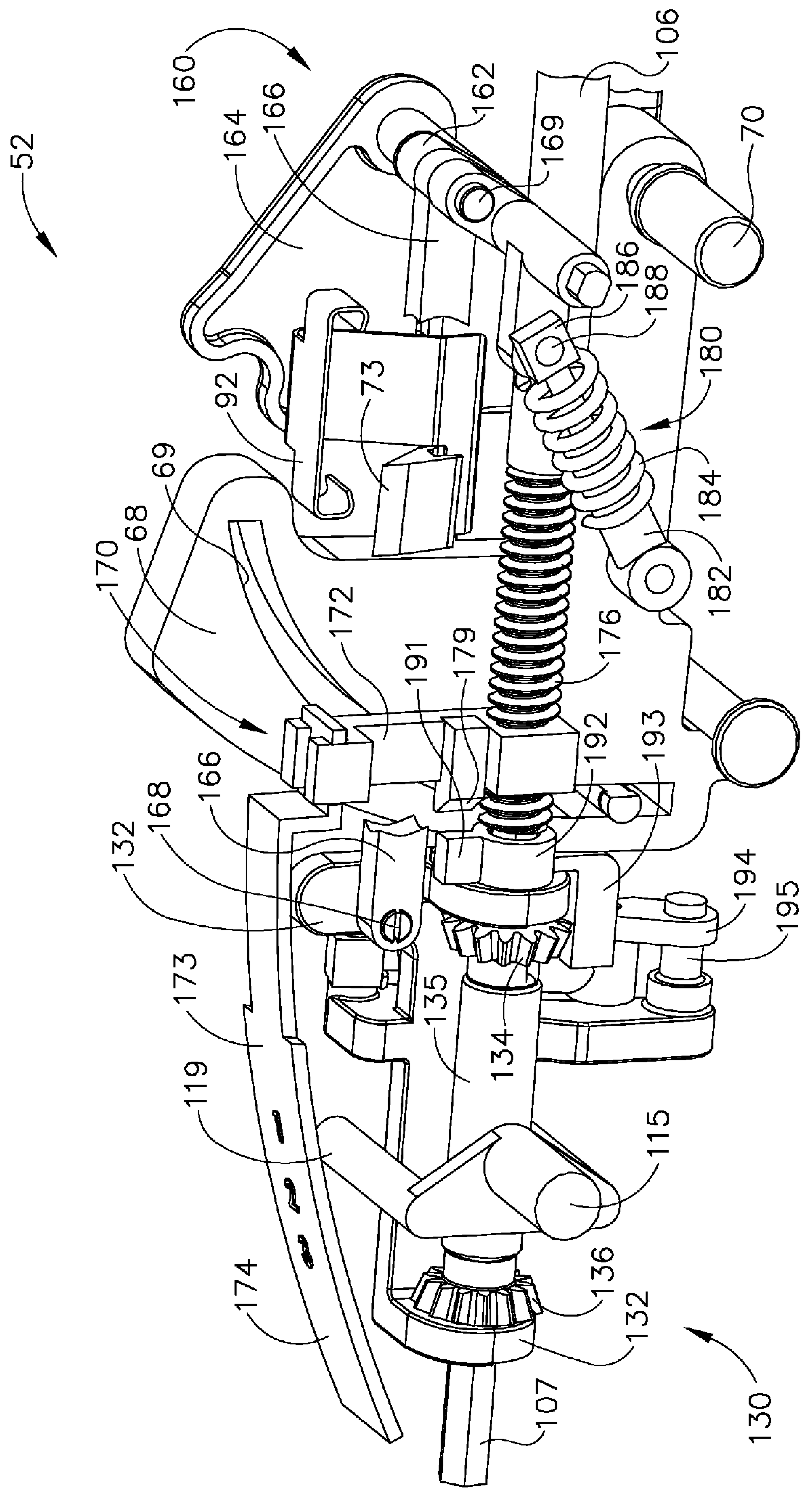

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FIG. 9

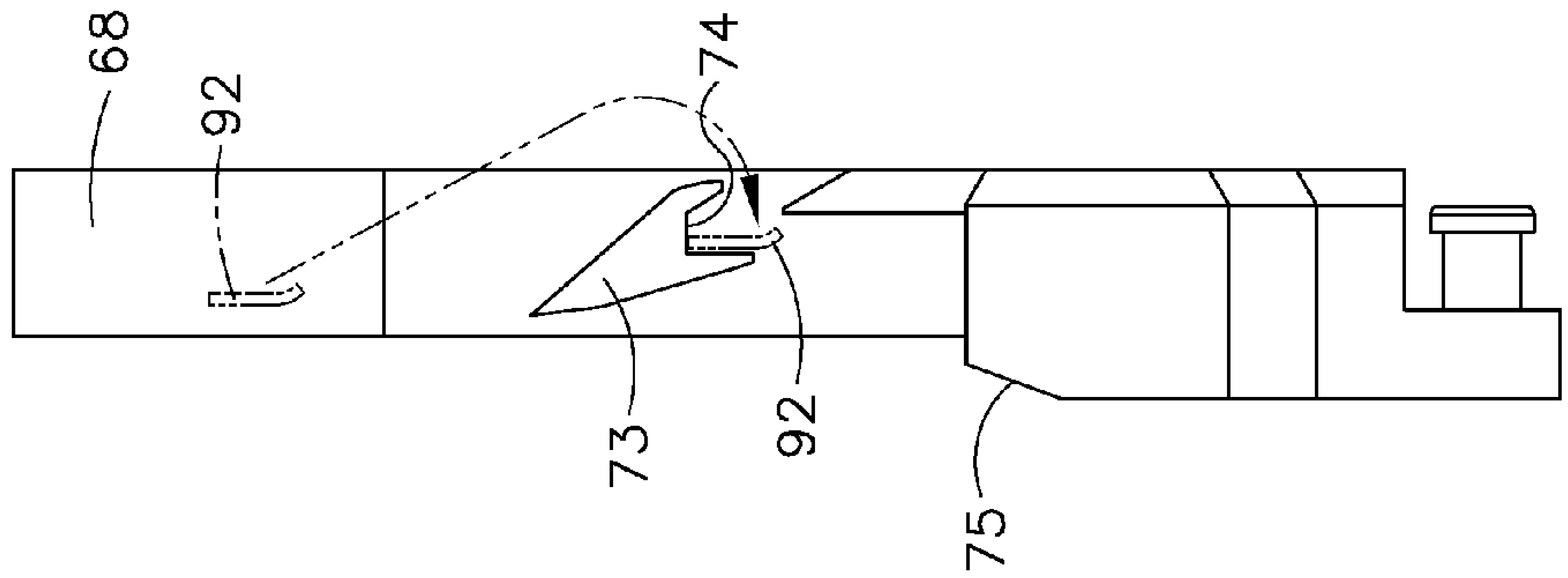


FIG. 11

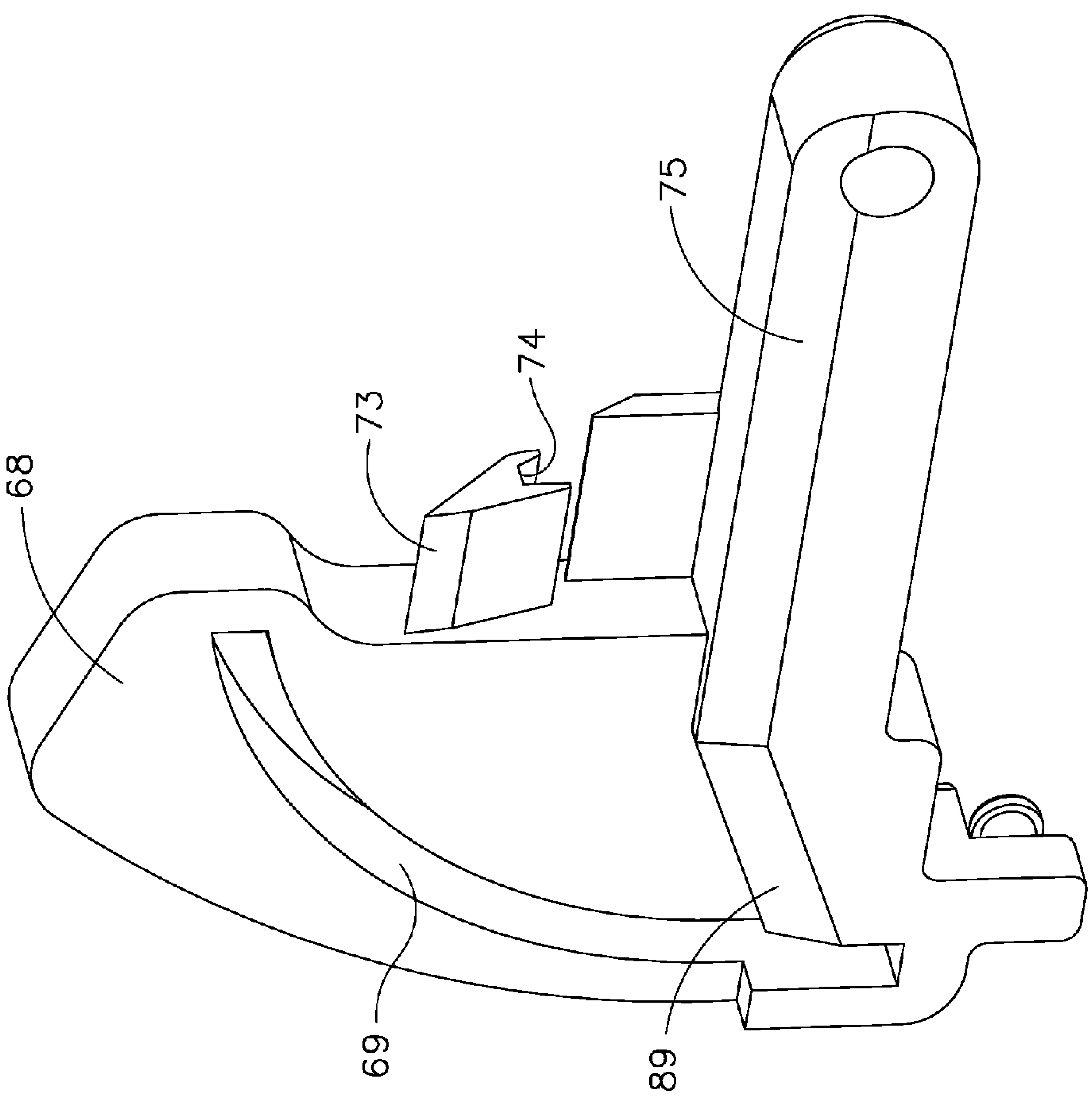
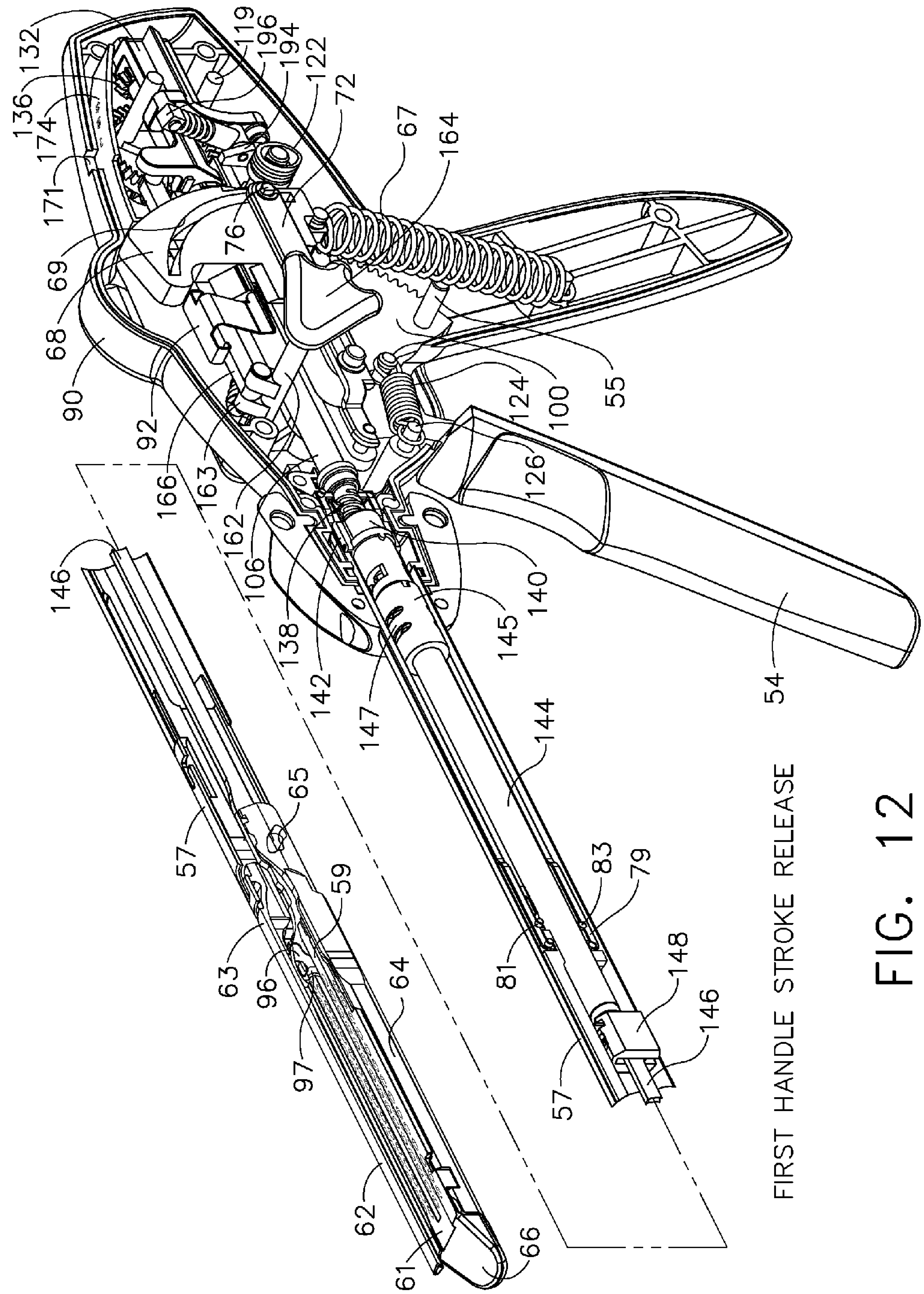


FIG. 10



FIRST HANDLE STROKE RELEASE

FIG. 12

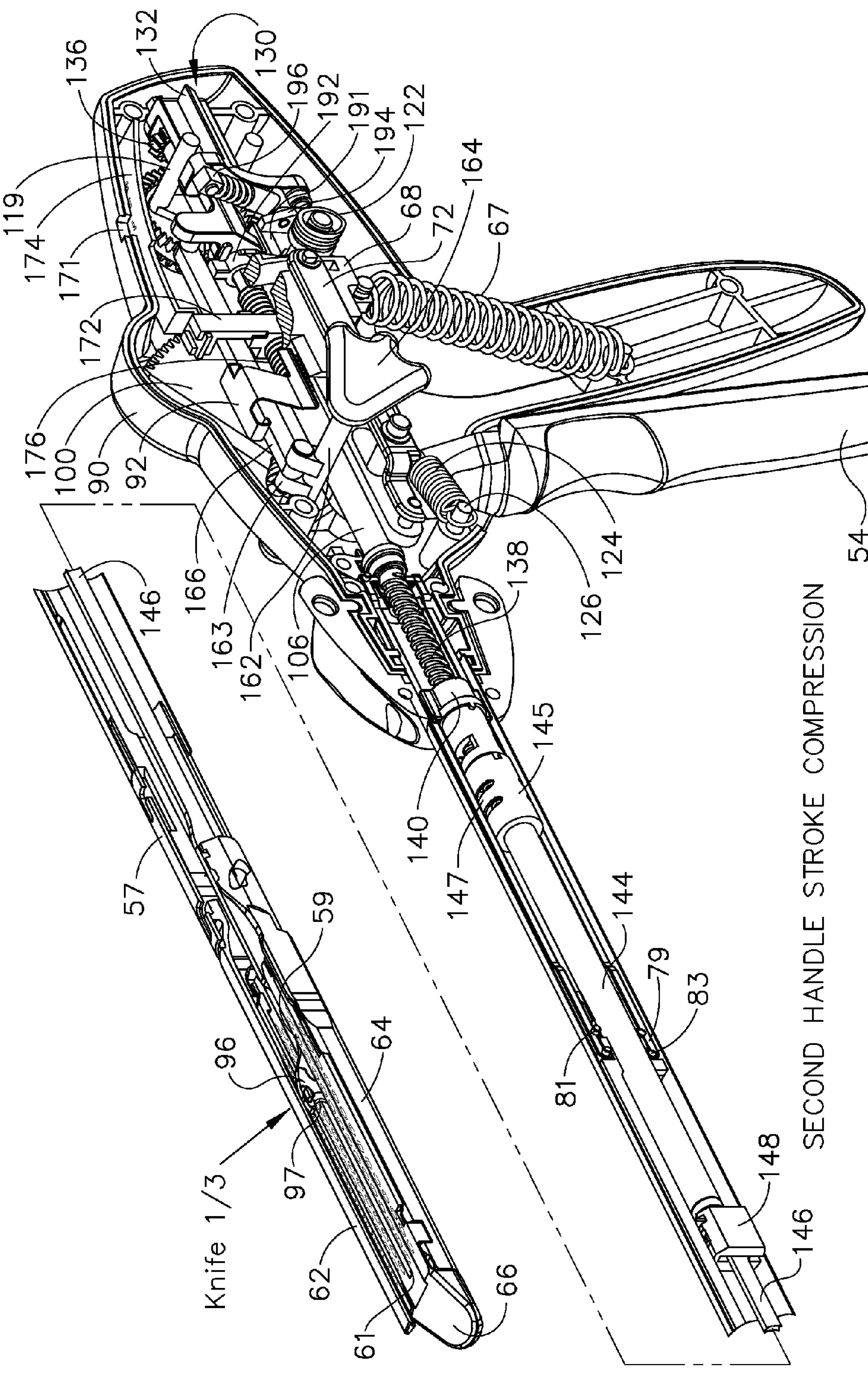

SECOND HANDLE STROKE COMPRESSION
Knife 1/3
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FIG. 13

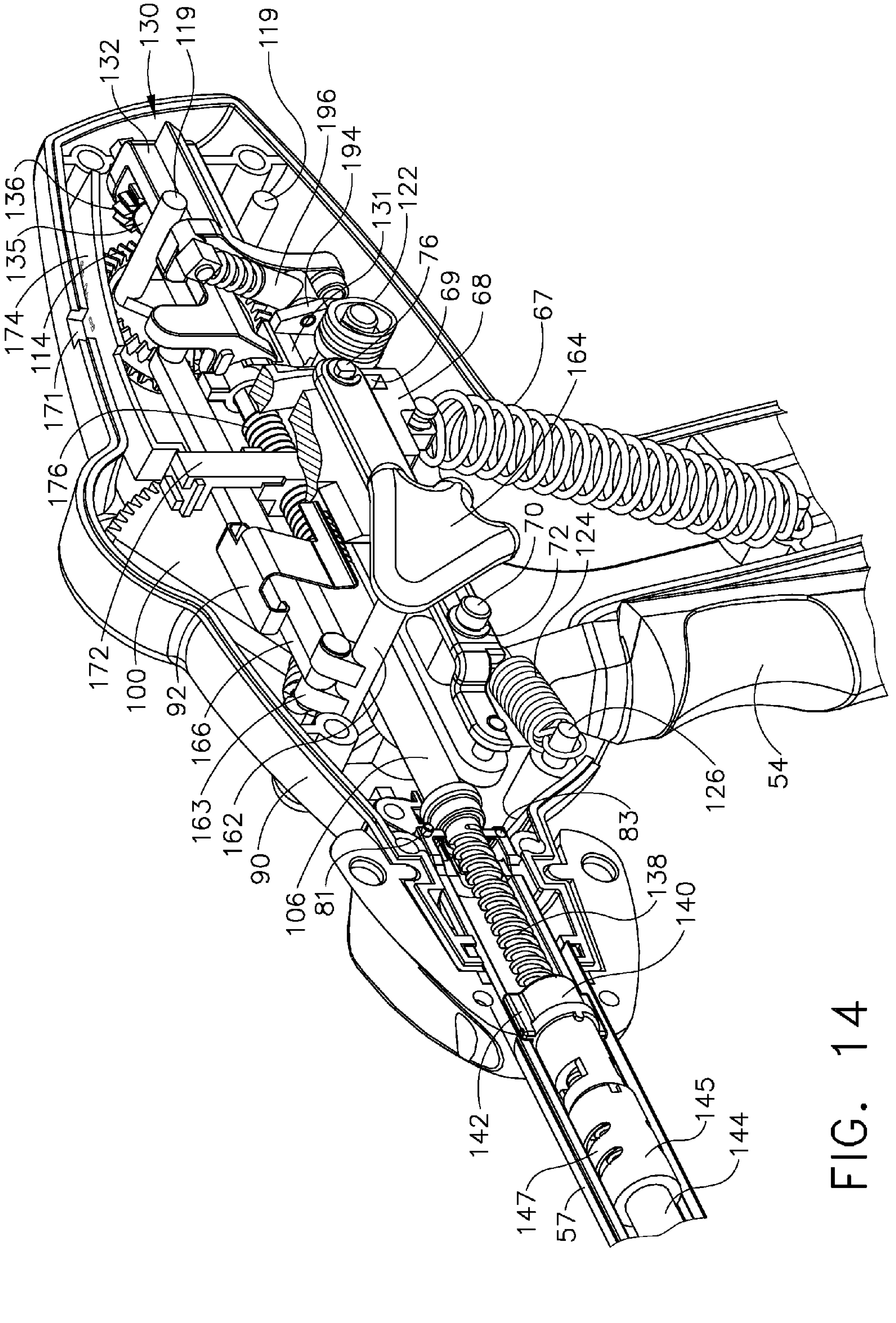
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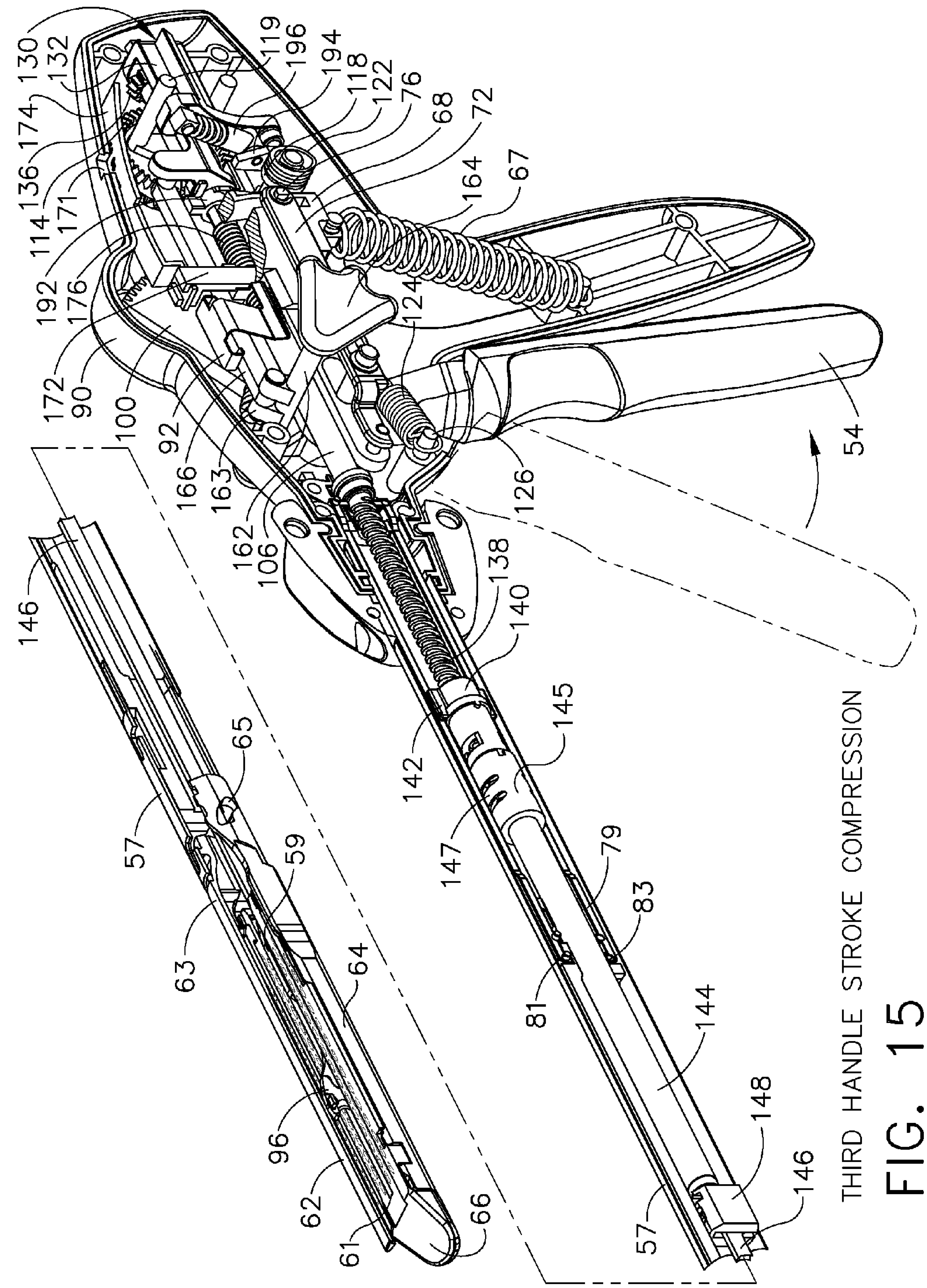
FIG. 14



THIRD HANDLE STROKE COMPRESSION

FIG. 15

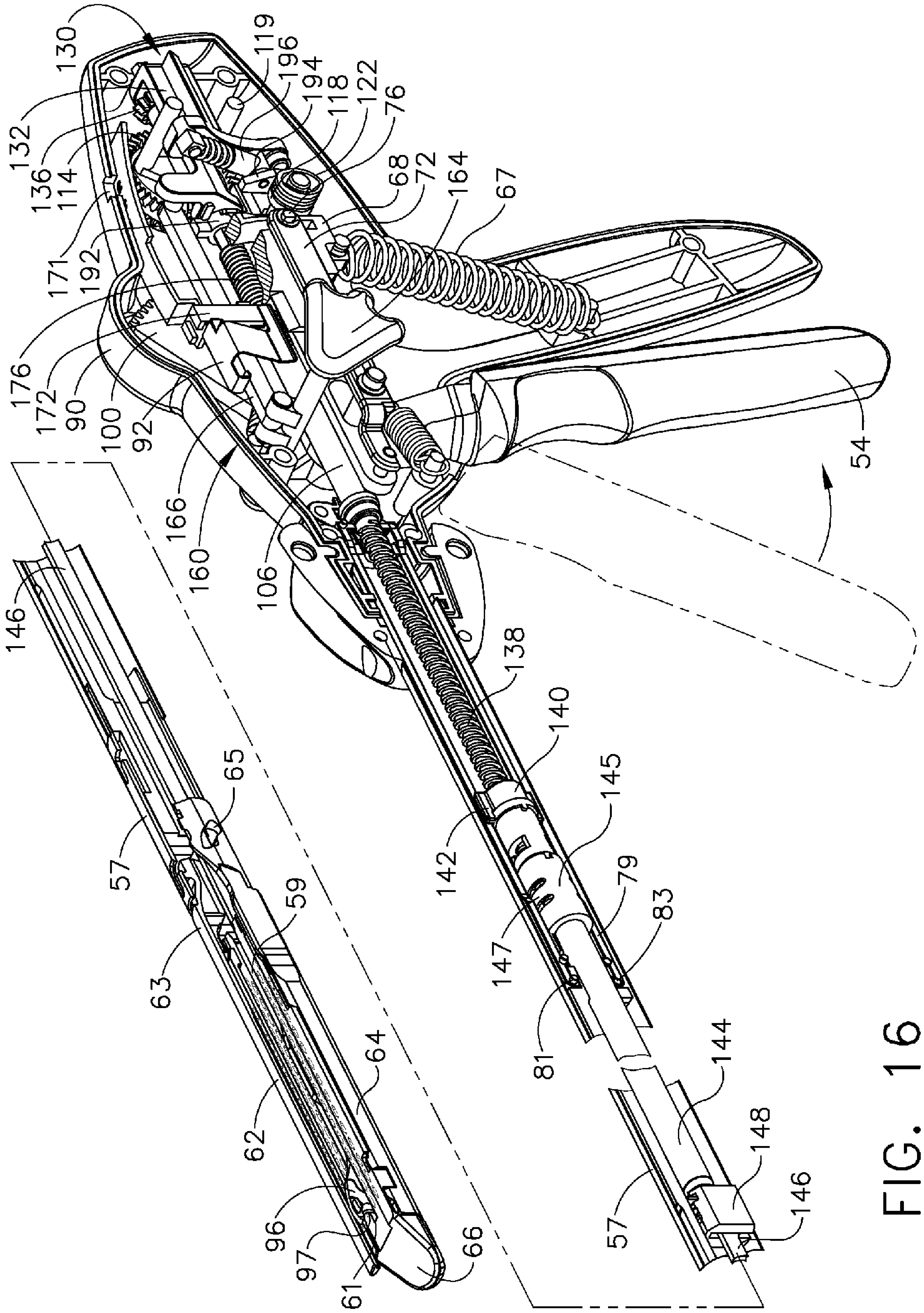

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FIG. 16

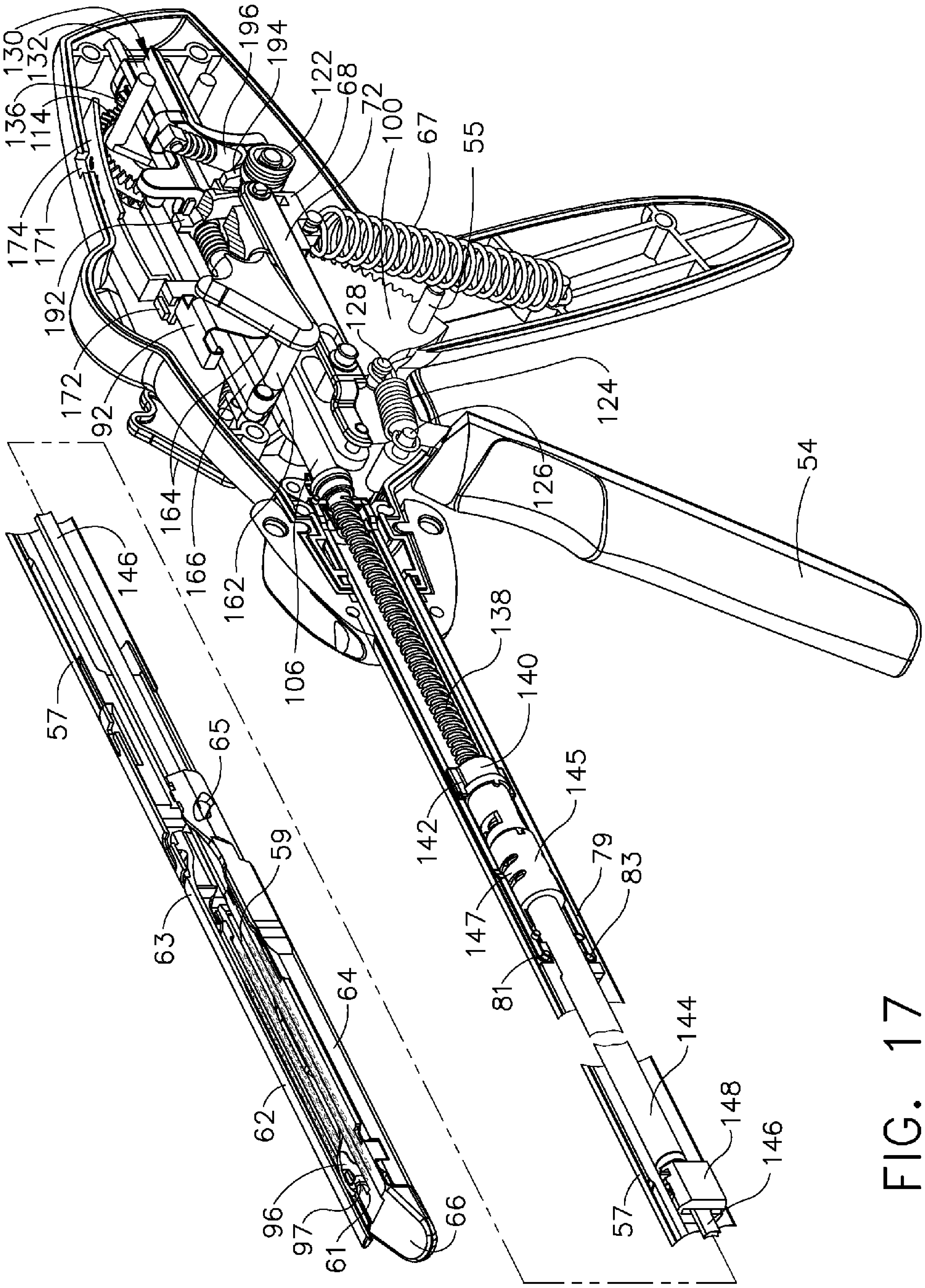
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FIG. 17

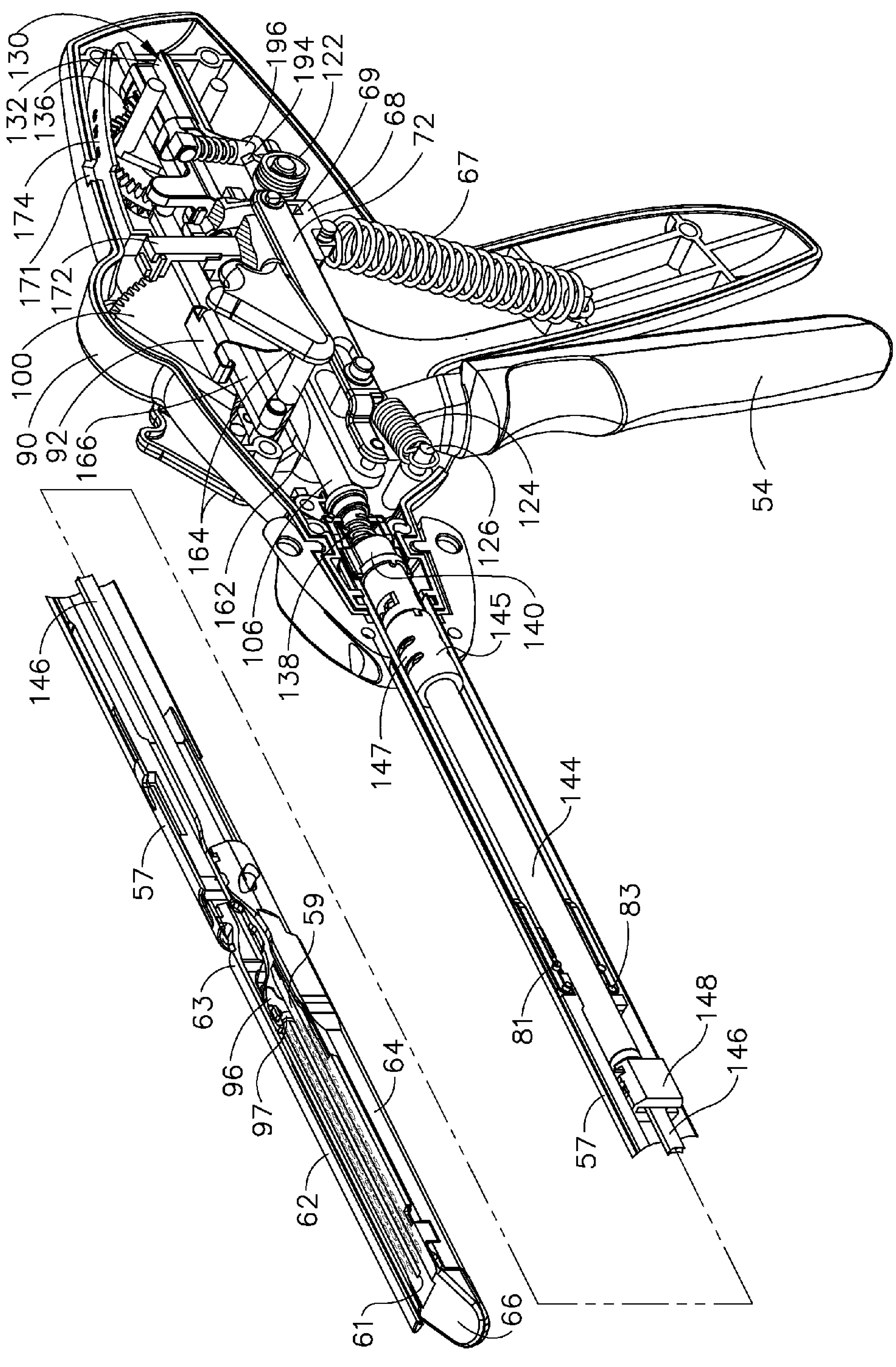

FIG. 18

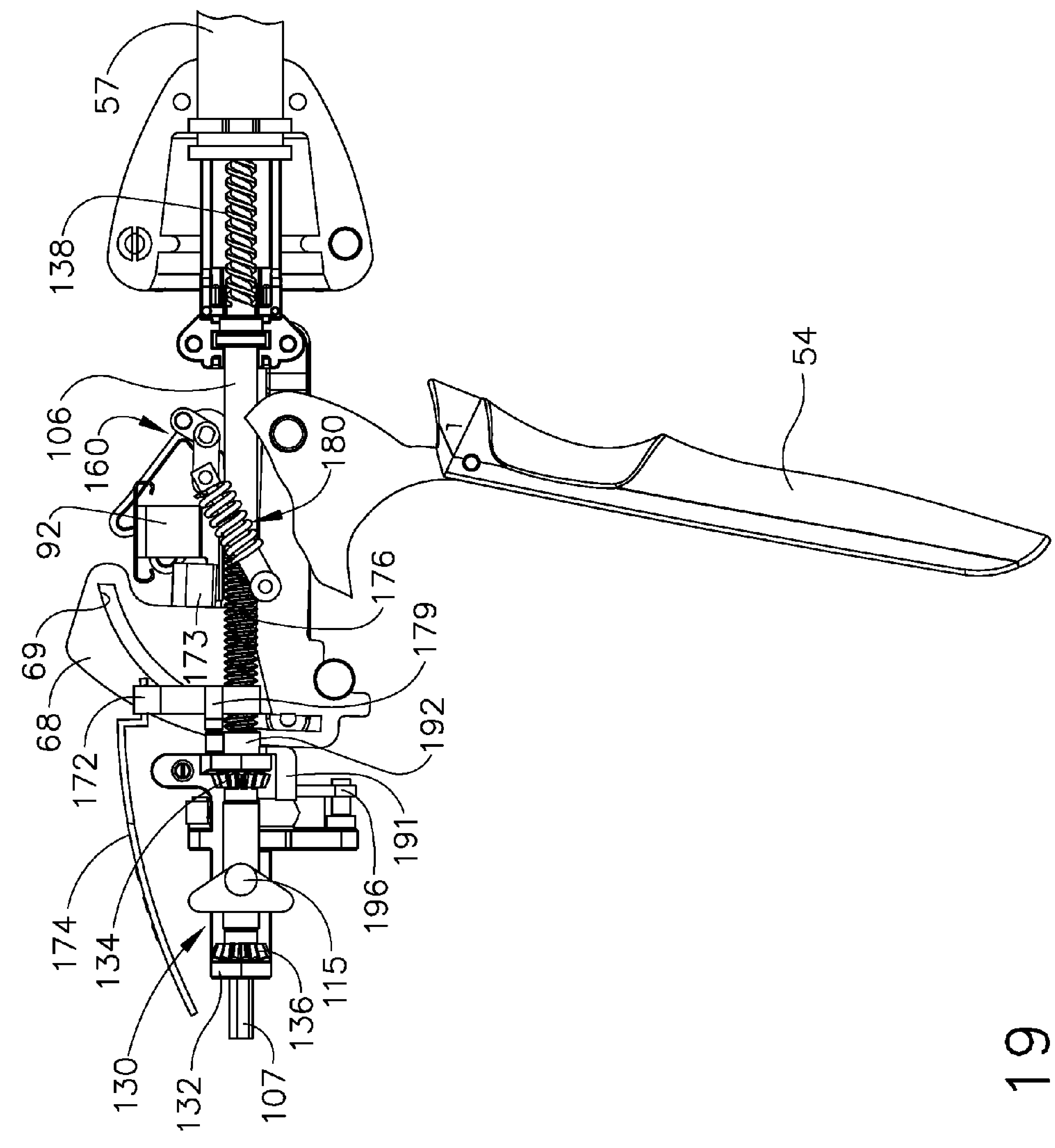
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FIG. 19

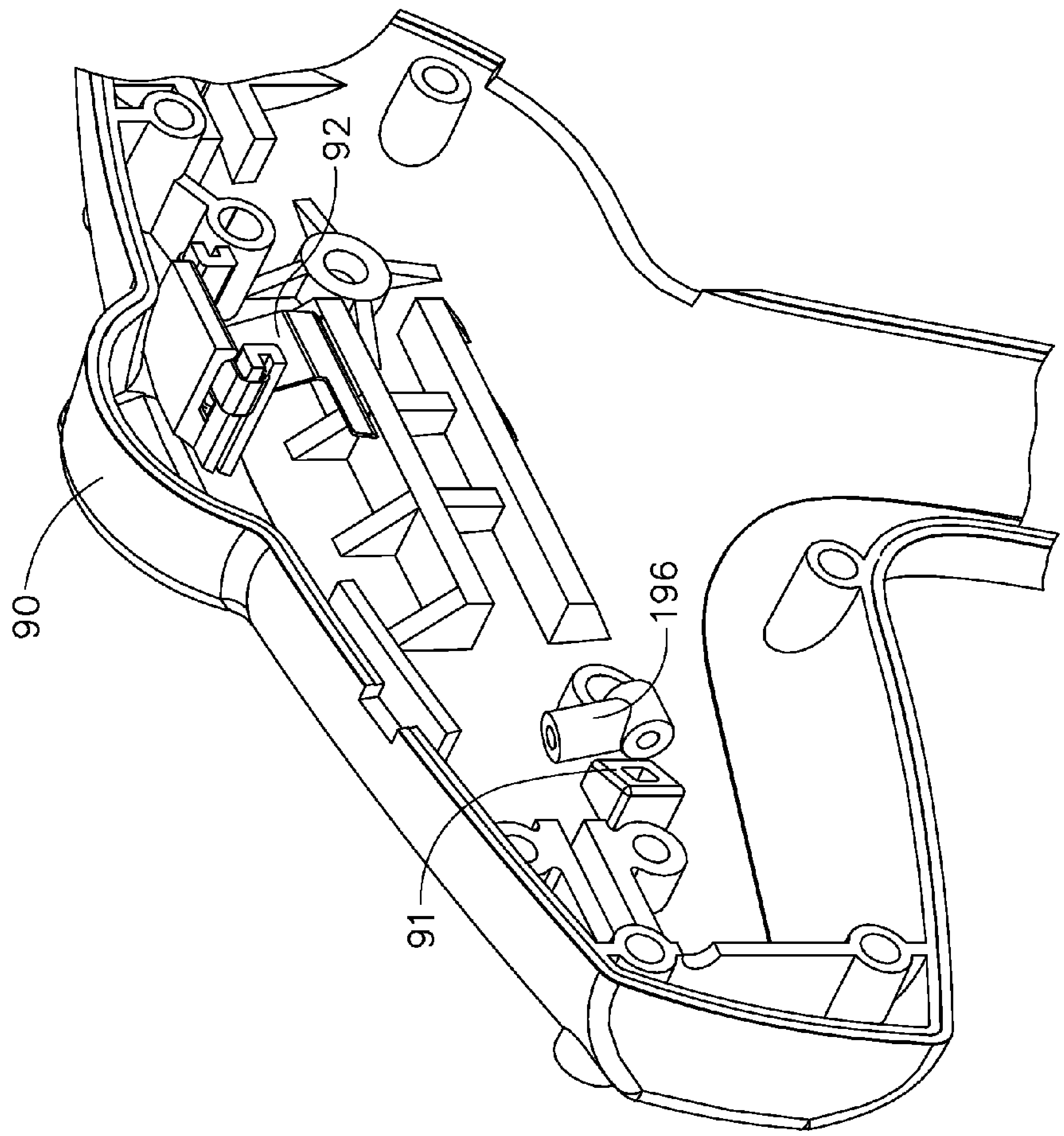

FIG. 20

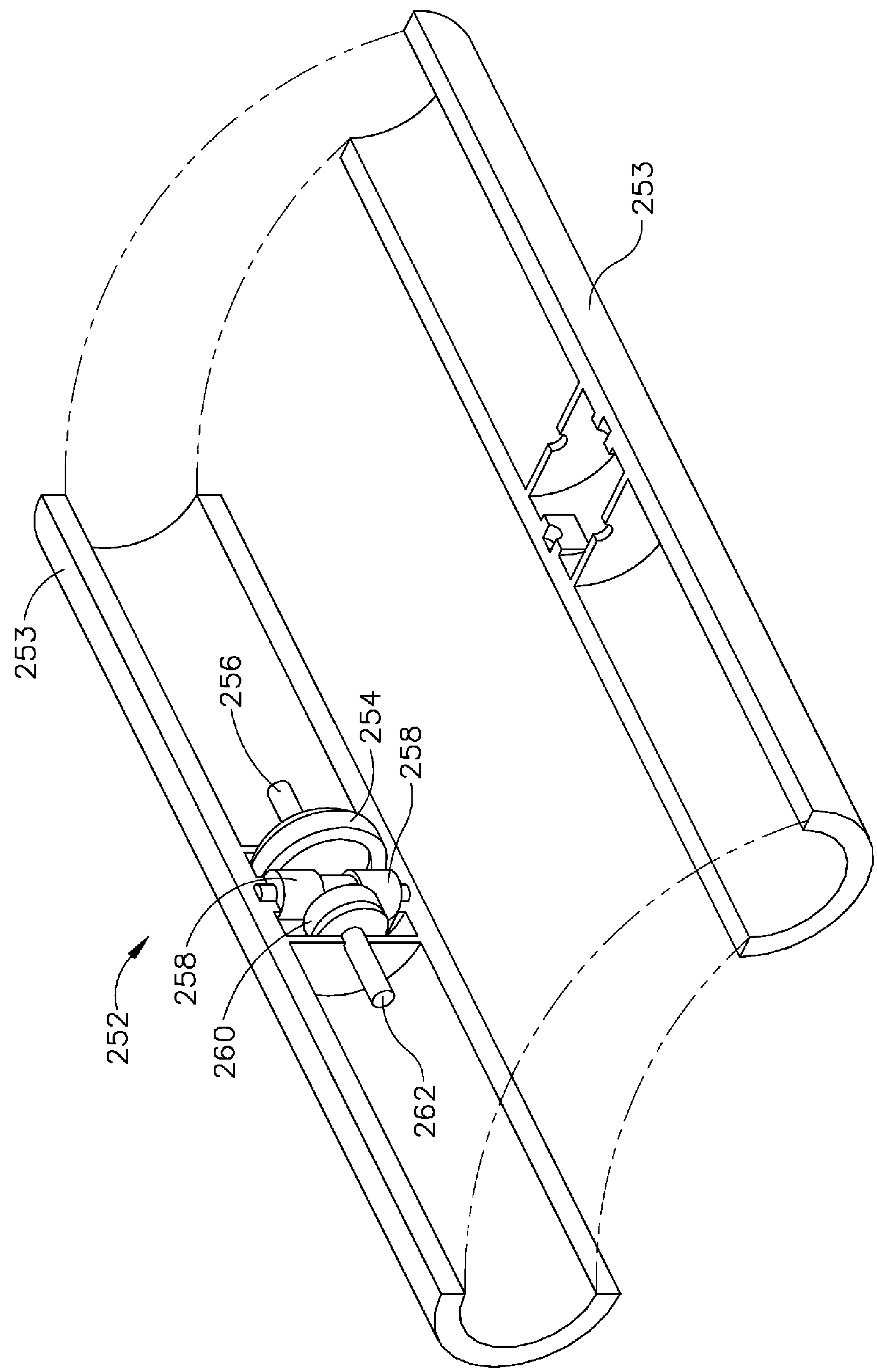

FIG. 21

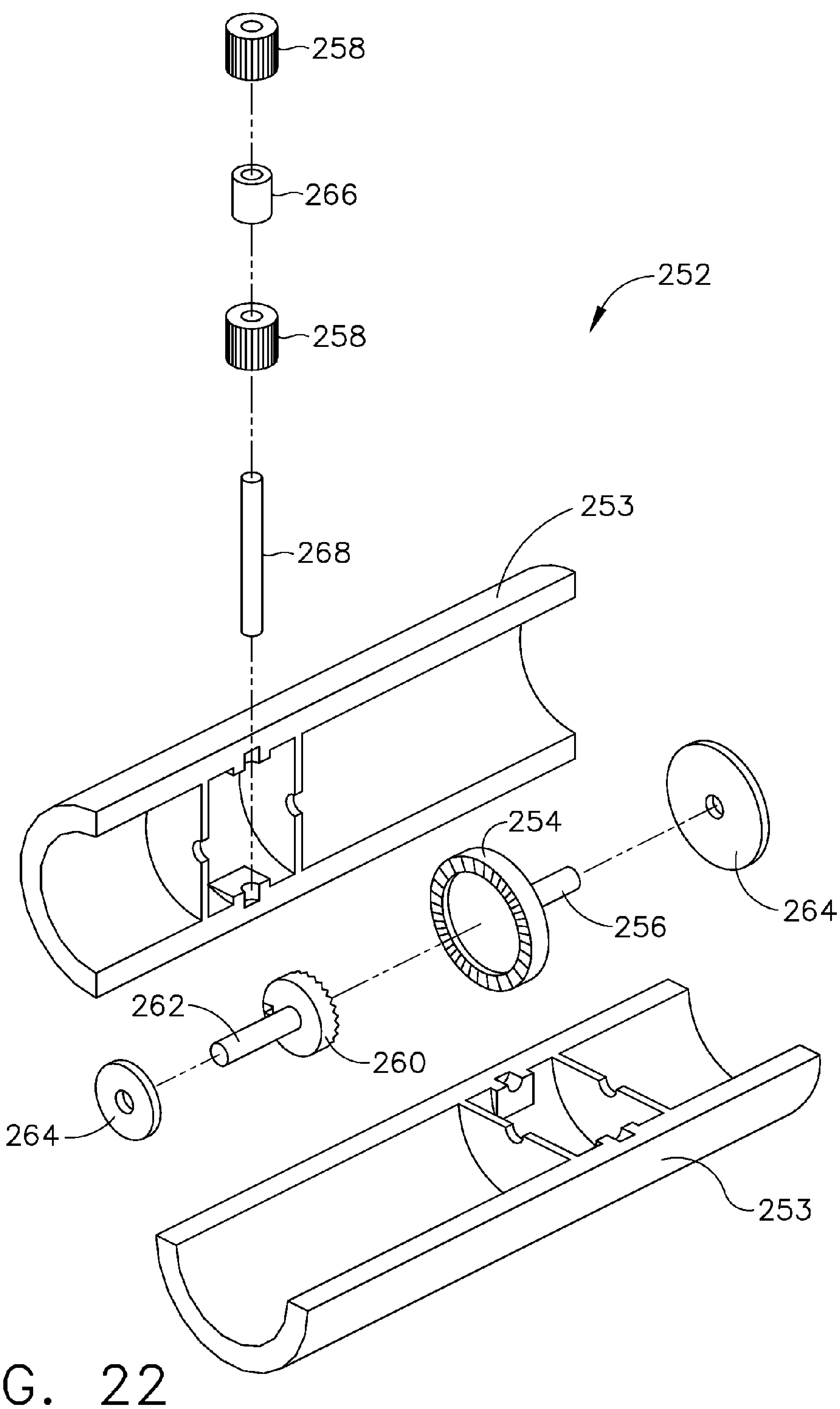

FIG. 22

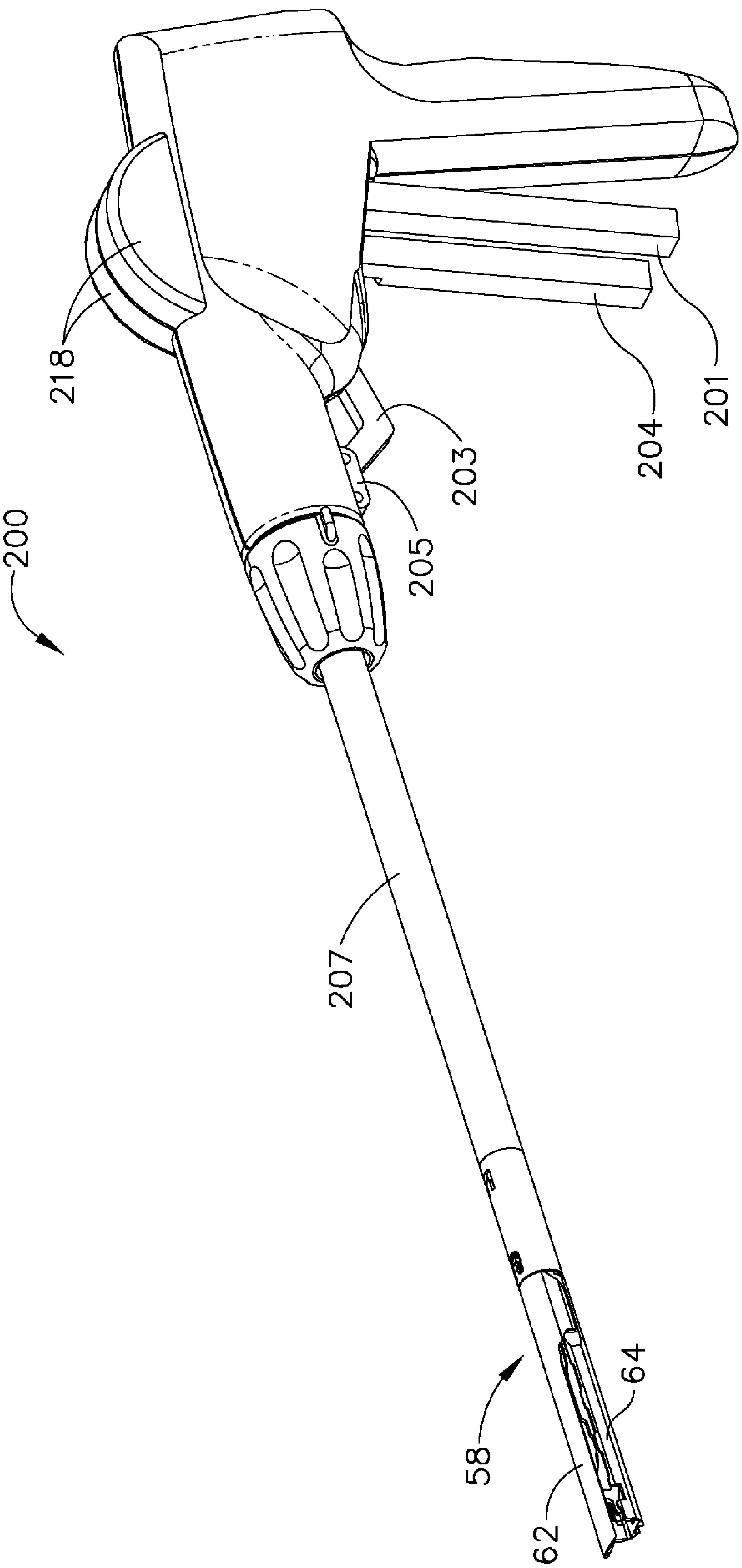

FIG. 23

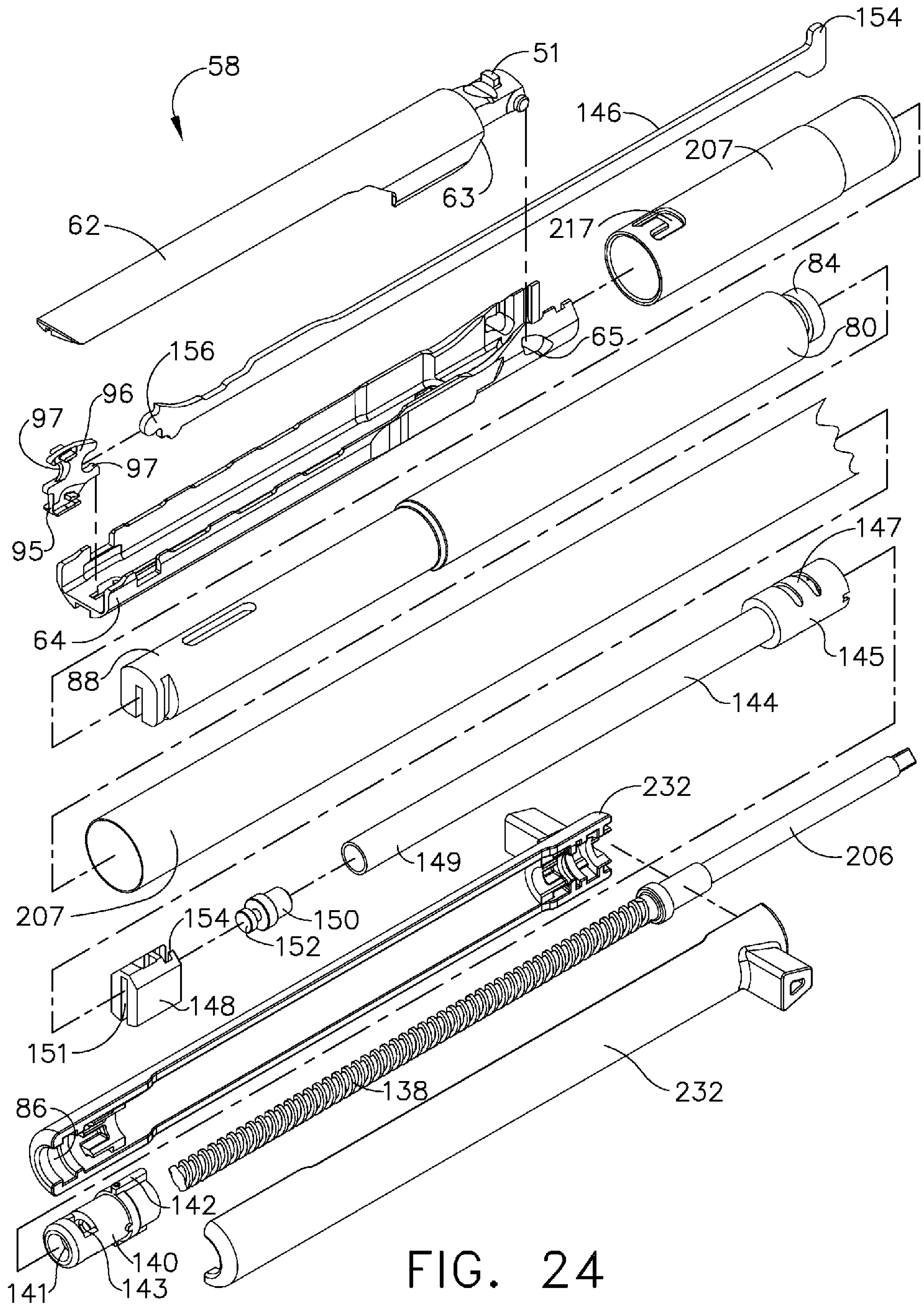
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FIG. 24

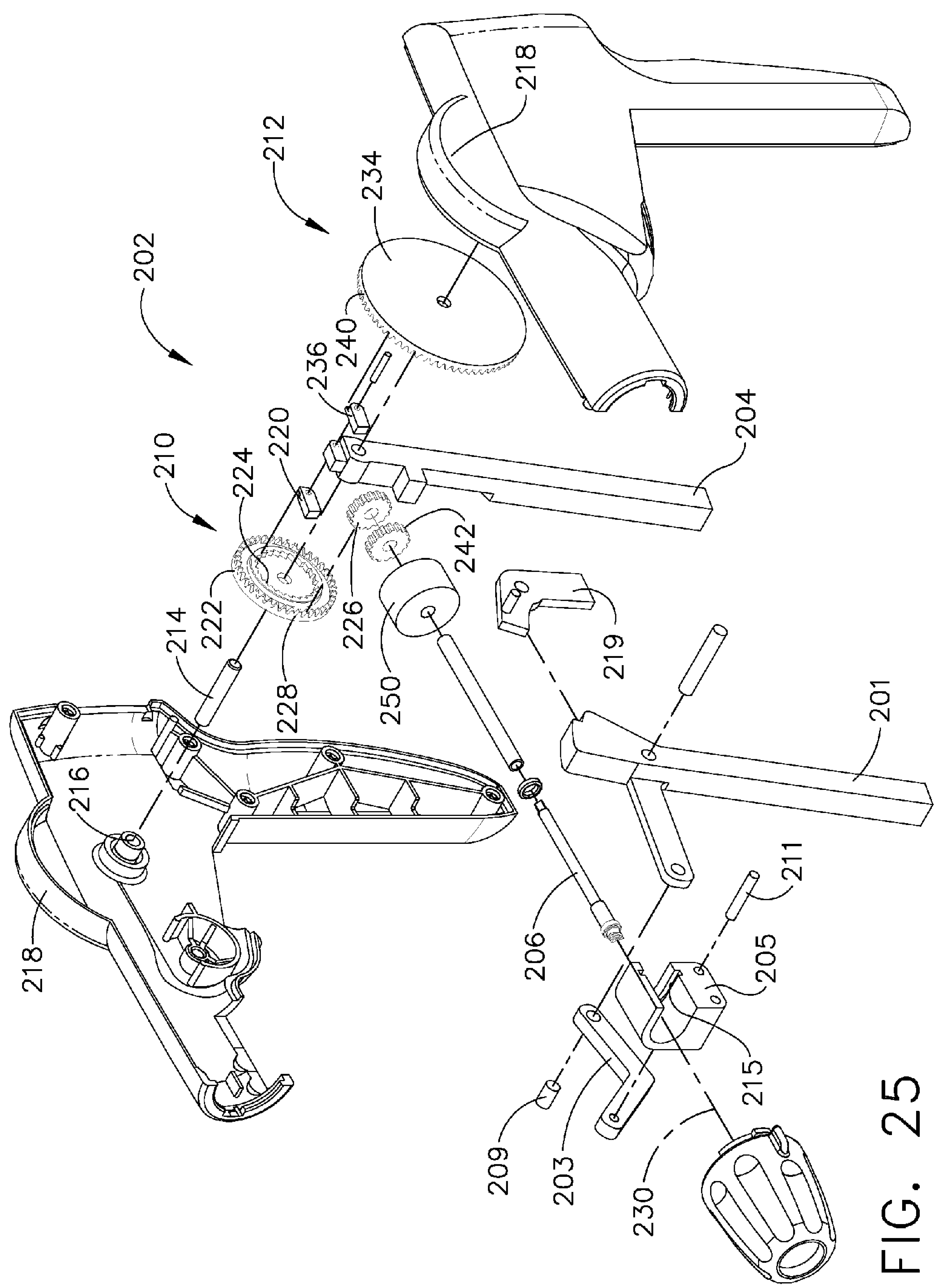
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FIG. 25

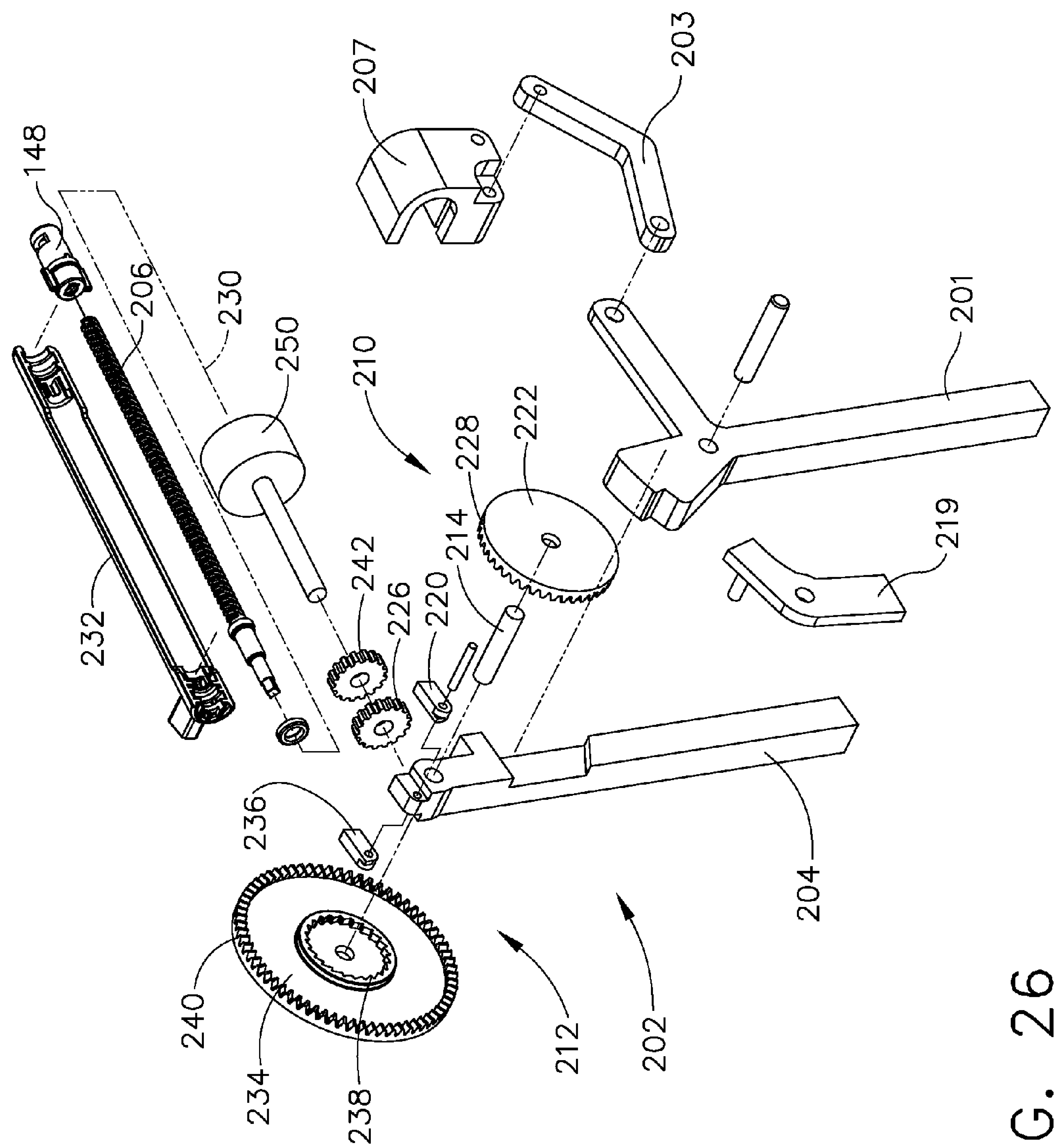
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FIG. 26

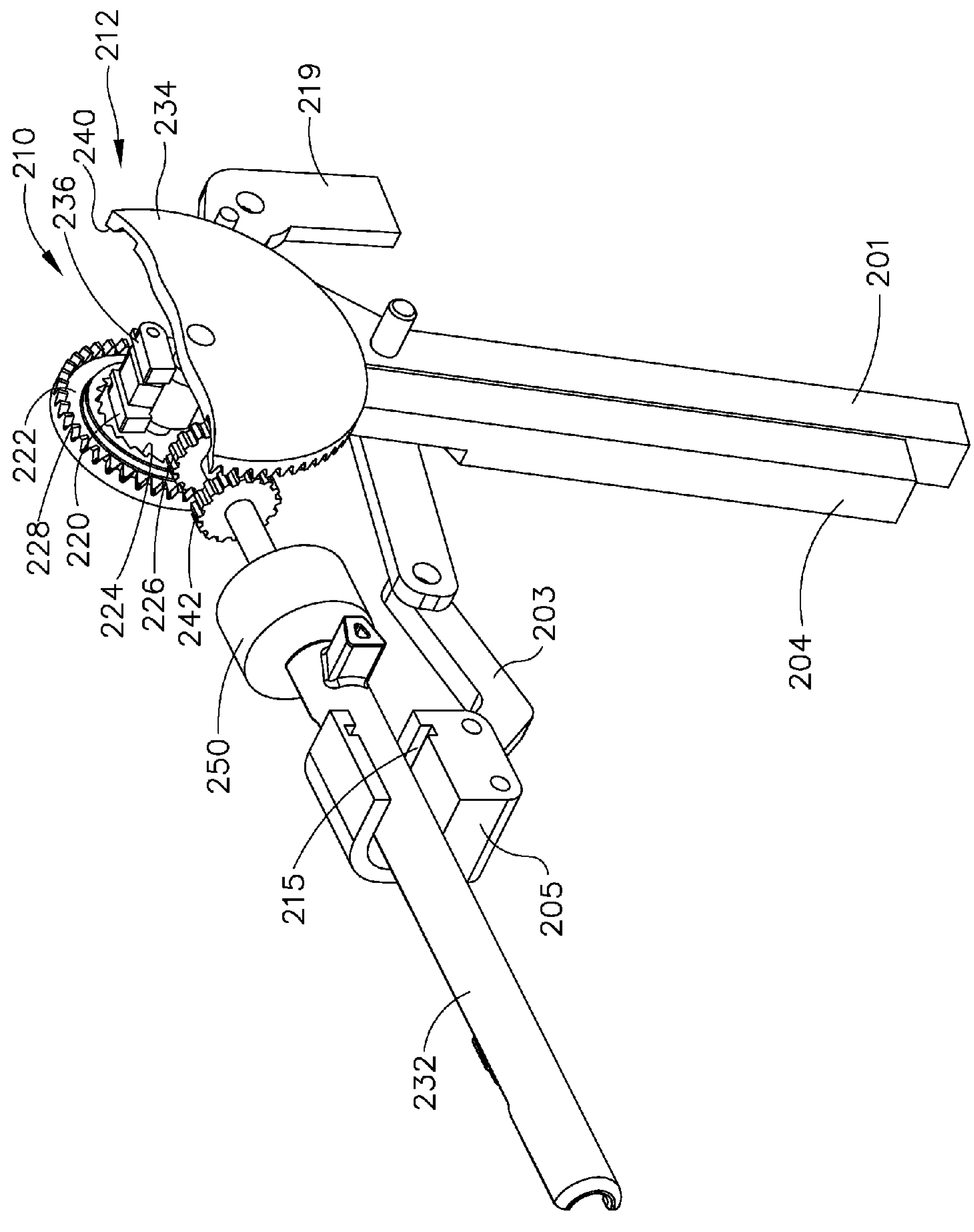
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FIG. 27

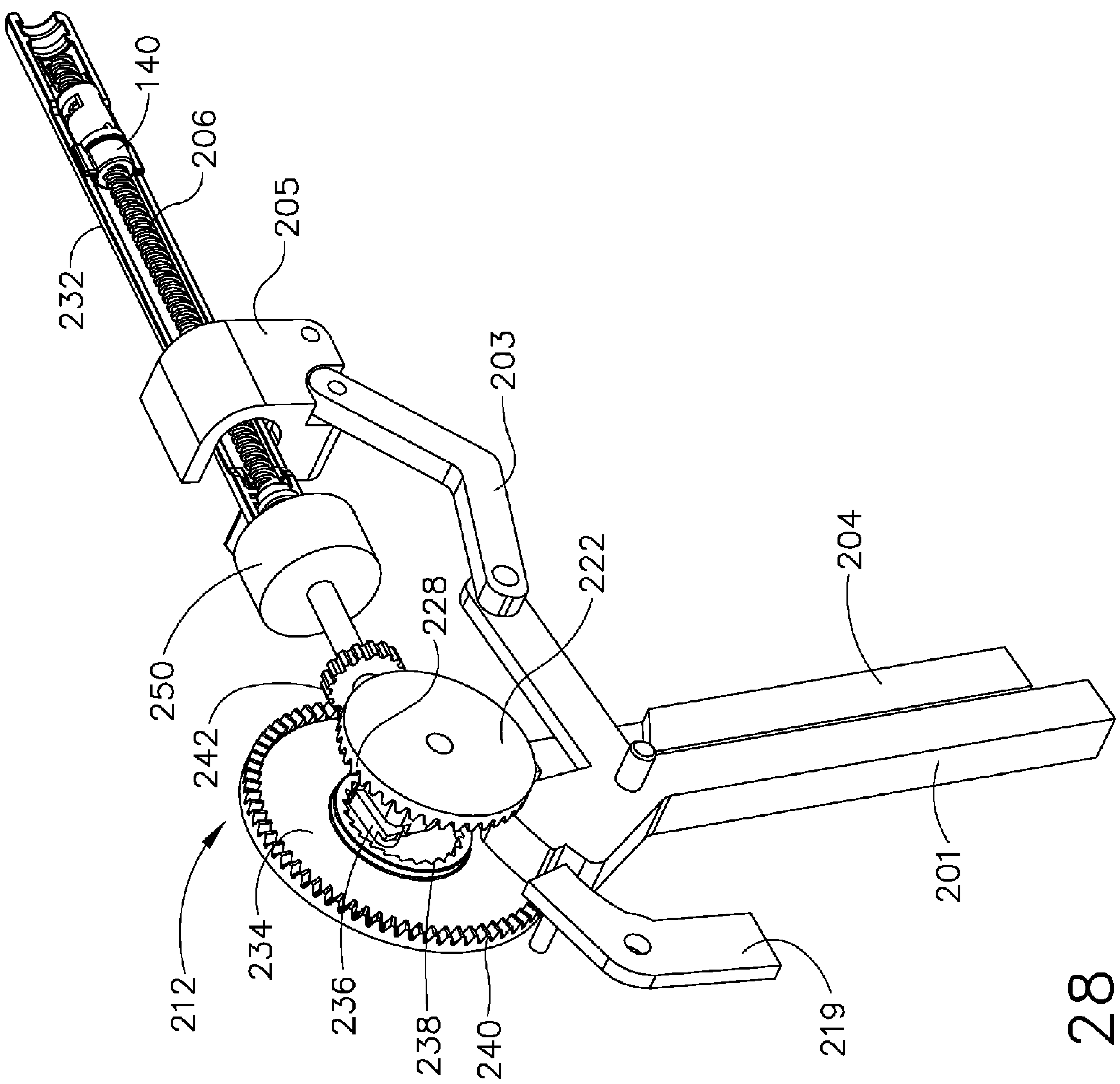
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FIG. 28

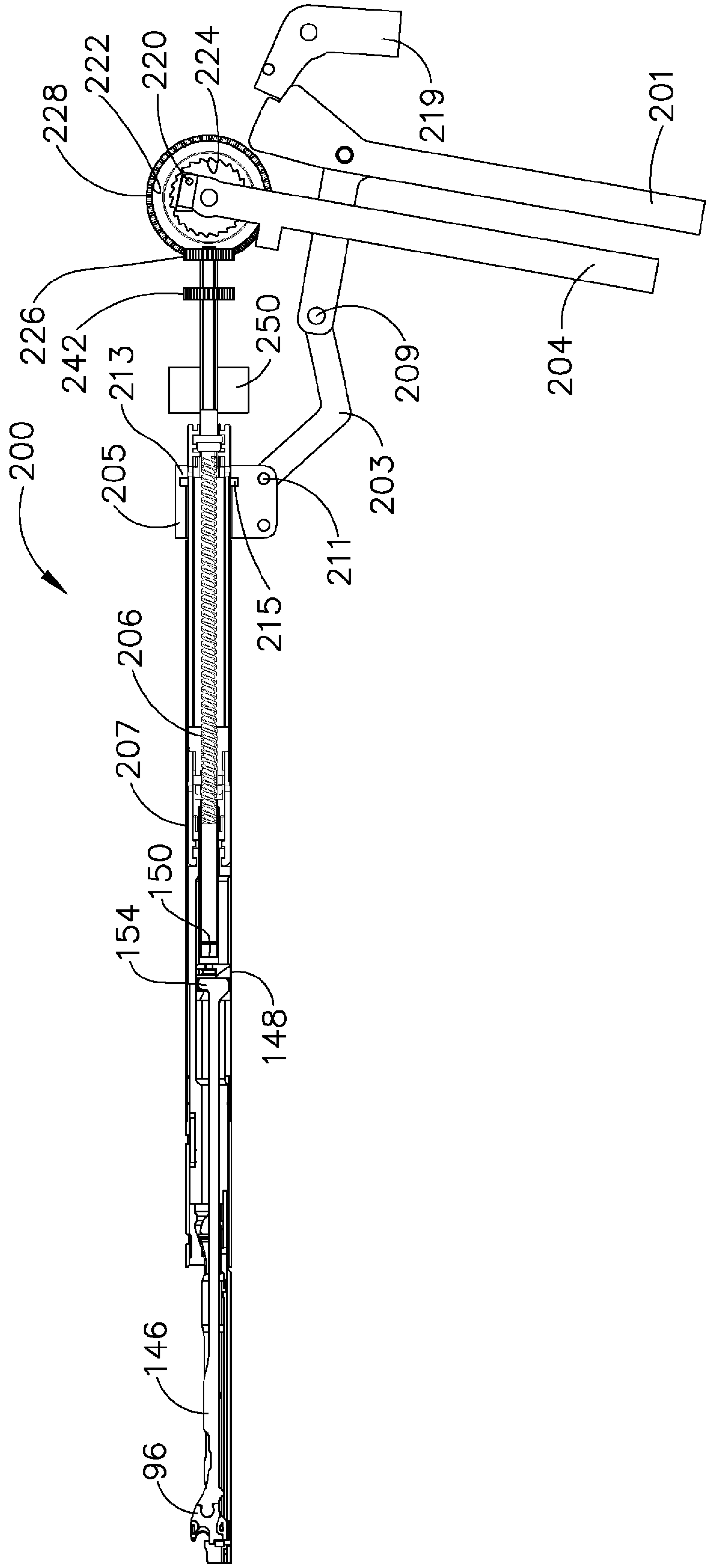
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FIG. 29

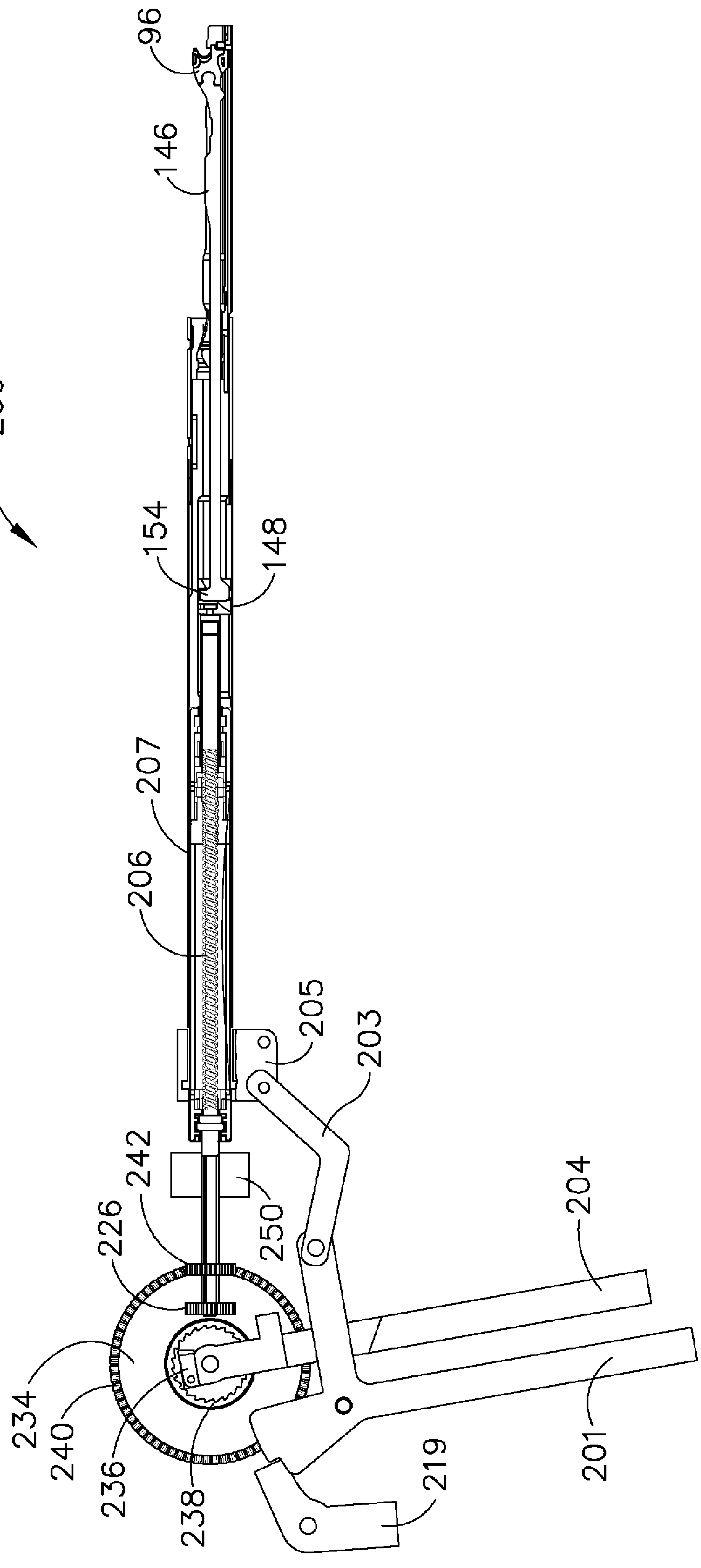
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FIG. 30

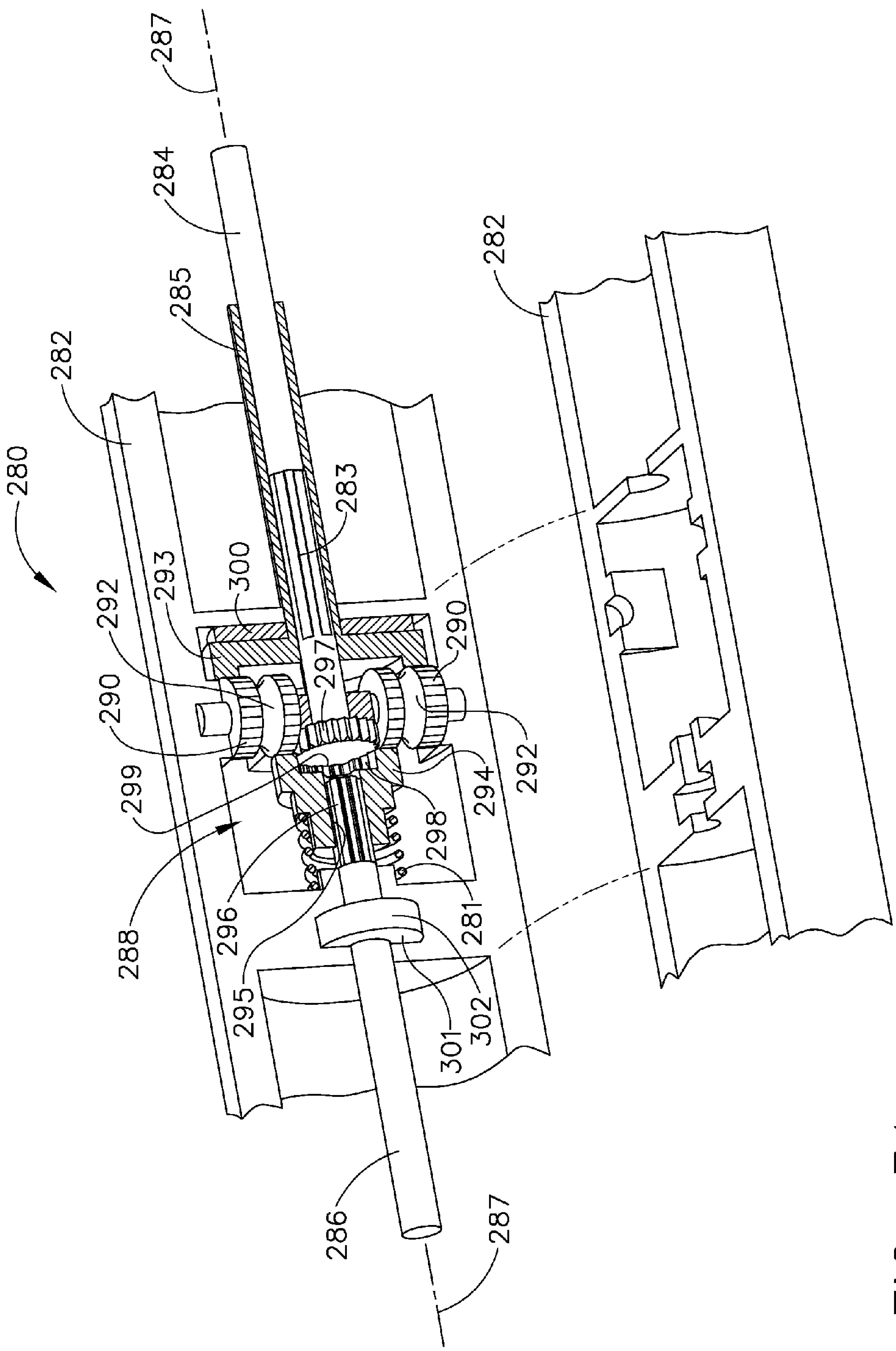
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FIG. 31

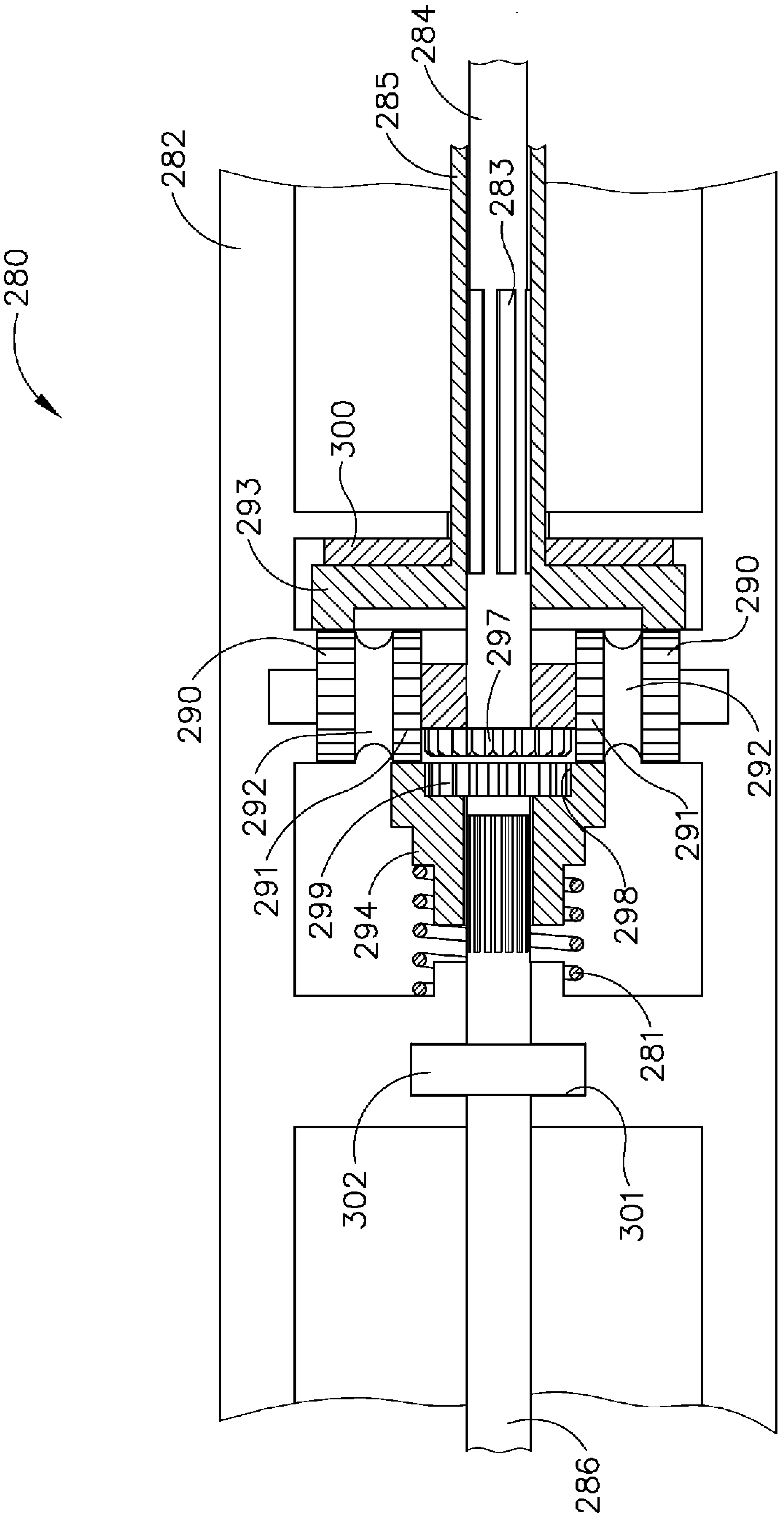
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FIG. 32

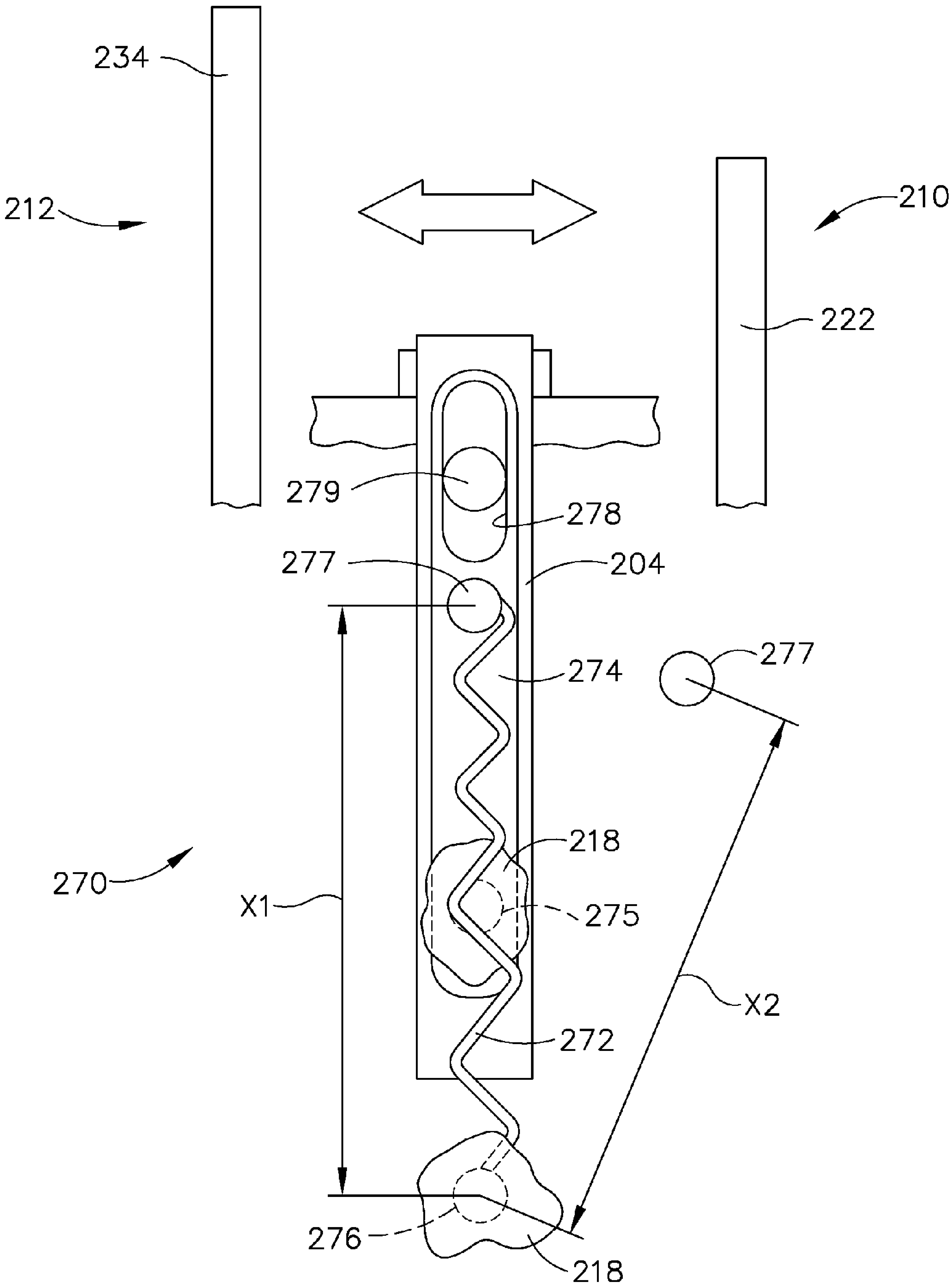
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FIG. 33

SURGICAL INSTRUMENT HAVING A MULTIPLE RATE DIRECTIONAL SWITCHING MECHANISM

CROSS-REFERENCE TO RELATED APPLICATIONS

This present application is a continuation-in-part which claims benefit of U.S. patent application Ser. No. 11/810,015, June 4, 2007, now U.S. Pat. No. 7,905,380, entitled: "Surgical Instrument Having a Multiple Rate Directional Switching Mechanism"; The present application is related to the following commonly-owned U.S. Patent Applications filed concurrently herewith, and which are hereby incorporated by reference in their entirety.

(1) U.S. patent application Ser. No. 11/810,016, entitled "SURGICAL INSTRUMENT HAVING A DIRECTIONAL SWITCHING MECHANISM", Issued on Nov. 16, 2010 as U.S. Pat. No. 7,832,408; and

(2) U.S. patent application Ser. No. 11/809,935, entitled "SURGICAL INSTRUMENT HAVING A COMMON TRIGGER FOR ACTUATING AN END EFFECTOR CLOSING SYSTEM AND A STAPLE FIRING SYSTEM", Issue on Oct. 26, 2010 as U.S. Pat. No. 7,819,299.

BACKGROUND

1. Field of the Invention

The present invention generally relates to surgical stapling instruments and, more particularly, to surgical staplers having an end effector closing system and a firing system for deploying staples.

2. Description of the Related Art

As known in the art, surgical staplers are often used to deploy staples into soft tissue to reduce or eliminate bleeding from the soft tissue, especially as the tissue is being transected, for example. Surgical staplers, such as an endocutter, for example, often comprise an end effector which is configured to secure the soft tissue between first and second jaw members. The first jaw member often includes a staple cartridge which is configured to removably store staples therein and the second jaw member often includes an anvil. In use, the staples are typically deployed from the staple cartridge by a driver which traverses a channel in the staple cartridge and causes the staples to be deformed against the anvil and secure layers of the soft tissue together. Often, as known in the art, the staples are deployed in several staple lines, or rows, in order to more reliably secure the layers of tissue together. The end effector may also include a cutting member, such as a knife, for example, which is advanced between two rows of the staples to resect the soft tissue after the layers of the soft tissue have been stapled together.

After the driver and the cutting member have been advanced within the end effector, it is often necessary to retract the driver and/or cutting member to their starting positions. Previous surgical staplers have included a return spring which retracts the cutting member relative to the staple cartridge after a release button or toggle switch on the surgical stapler has been actuated by the surgeon. Such staplers, however, are unable to partially retract the cutting member and, as a result, the cutting member must be fully retracted before it can be readvanced. Other previous surgical staplers have included a plurality of triggers which are operatively engaged with systems for closing a jaw member and for advancing and/or retracting the driver and cutting member. Such devices, while suitable for their intended purposes, often require a surgeon to release a trigger operably engaged with the closing system and reposition their hand to grasp a different trigger which is operatively engaged with a system for advancing the staple driver and cutting member. While previous surgical staplers have been developed which have a single trigger for both closing the jaw member and advancing the driver and cutting member, such devices perform both functions upon the initial actuation of the trigger. While suitable in some circumstances, devices which perform both functions in the same trigger actuation are often exceedingly difficult to operate owing to the high degree of force required to actuate the trigger. Furthermore, such devices, as they close the jaw member and deploy staples in the same trigger actuation, do not afford the surgeon with an opportunity to evaluate the position of the closed jaw member and reposition the jaw member before the staples are deployed into the soft tissue. What is needed is an improvement over the foregoing.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of the various embodiments of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a perspective view of a surgical instrument in accordance with an embodiment of the present invention;

FIG. **2** is an exploded view of a shaft portion and end effector of the surgical instrument of FIG. **1**;

FIG. **3** is an exploded view of a handle portion of the surgical instrument of FIG. **1**;

FIG. **4** is partial side view of the handle portion of FIG. **3** with some components of the surgical instrument removed;

FIG. **5** is a top view of the handle portion of FIG. **3** with some components of the surgical instrument removed illustrating the surgical instrument in a configuration for advancing a cutting member in the end effector;

FIG. **6** is a bottom view of the handle portion of FIG. **3** with some components of the surgical instrument removed illustrating the surgical instrument in a configuration for advancing a cutting member in the end effector;

FIG. **7** is a partial perspective view of the handle portion of FIG. **3** with some components of the surgical instrument removed;

FIG. **8** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument upon the first actuation of the trigger;

FIG. **9** is a partial perspective view of the surgical instrument of FIG. **1** in the configuration illustrated in FIG. **8** with some components of the surgical instrument removed;

FIG. **10** is a perspective view of a cam of the end effector closure system of the surgical instrument of FIG. **1**;

FIG. **11** is an elevational view of the cam of FIG. **10** illustrating various relative positions of a lock of the anvil closure system;

FIG. **12** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument after the trigger has been released after the first actuation of the trigger;

FIG. **13** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument upon the second actuation of the trigger;

FIG. **14** is a partial perspective view of the surgical instrument of FIG. **1** in the configuration illustrated in FIG. **13**;

FIG. **15** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument upon the third actuation of the trigger;

FIG. **16** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument upon the fourth actuation of the trigger;

FIG. **17** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument after the trigger has been released after the fourth actuation of the trigger and the switching mechanism of the surgical instrument has been operated;

FIG. **18** is a perspective view of the surgical instrument of FIG. **1** illustrating the configuration of the surgical instrument upon the seventh actuation of the trigger with the cutting member fully retracted;

FIG. **19** is a partial elevational view of the surgical instrument of FIG. **1** illustrated in the configuration of FIG. **18** with components of the surgical instrument removed;

FIG. **20** is a partial perspective view of the housing of the surgical instrument of FIG. **1** illustrating the interaction of the firing drive and the housing after the seventh actuation of the trigger;

FIG. **21** is a perspective view of a gear reduction mechanism for a surgical instrument in accordance with an alternative embodiment of the present invention with a portion of the gear reduction housing disassembled;

FIG. **22** is an exploded view of the gear reduction mechanism of FIG. **21**;

FIG. **23** is a perspective view of a surgical instrument in accordance with an alternative embodiment of the present invention;

FIG. **24** is an exploded view of the end effector and shaft assembly of the surgical instrument of FIG. **23**;

FIG. **25** is an exploded view of the handle portion of the surgical instrument of FIG. **23**;

FIG. **26** is an exploded view of the surgical instrument of FIG. **23** with components of the surgical instrument removed;

FIG. **27** is a perspective view of the surgical instrument of FIG. **23** with components of the surgical instrument removed;

FIG. **28** is a second perspective view of the surgical instrument of FIG. **23** with components of the surgical instrument removed;

FIG. **29** is a side view of the surgical instrument of FIG. **23** configured to advance a cutting member within the end effector;

FIG. **30** is a side view of the surgical instrument of FIG. **23** configured to retract the cutting member within the end effector;

FIG. **31** is a perspective view of a directional switching mechanism in accordance with an alternative embodiment of the present invention with some components disassembled and other components illustrated in cross-section;

FIG. **32** is a plan view of the directional switching mechanism of FIG. **31** with some components removed and other components illustrated in cross-section; and

FIG. **33** is a diagram of a bistable compliant mechanism in accordance with an alternative embodiment of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate preferred embodiments of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION

Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the various embodiments of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

In various embodiments, a surgical instrument in accordance with the present invention can include systems for inserting surgical staples into soft tissue, for example. In at least one embodiment, the surgical instrument can include a staple cartridge configured to removably store staples therein and an anvil for deforming the staples as they are deployed from the staple cartridge. In order to deploy the staples, the surgical instrument can include a staple driver configured to traverse the staple cartridge and a firing drive for advancing the staple driver within the staple cartridge. In various embodiments, the firing drive can include a drive bar which is translated in a substantially linear direction by a trigger operably engaged therewith. In other embodiments, the firing drive can include a drive shaft which is rotated by the trigger. In such embodiments, the surgical instrument can include a shaft assembly which can convert the rotary motion of the drive shaft into linear motion and translate the staple driver within the staple cartridge. While the exemplary embodiment illustrated in FIGS. **1-20** and described below includes a firing drive having a rotary drive shaft, the present invention is not so limited. Furthermore, while a general description of a firing drive having a rotary drive shaft is provided below, other such devices are described and illustrated in greater detail in the commonly-owned, co-pending U.S. patent application Ser. No. 11/475,412, entitled MANUALLY DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT and filed on Jun. 27, 2006, the entire disclosure of which is hereby incorporated by reference herein.

Referring to FIG. **1**, surgical instrument **50** can include handle portion **52**, trigger **54**, elongate shaft assembly **56**, and end-effector **58**. In various embodiments, end-effector **58** can include anvil **62** and staple cartridge channel **64**, where channel **64** can be configured to receive staple cartridge **66** and anvil **62** can be pivotably connected to channel **64**. In at least one embodiment, at least one of anvil **62** and channel **64** can be operably connected to trigger **54** such that, upon an actuation of trigger **54**, anvil **62** can be rotated into a closed position as illustrated in FIG. **8**. In various embodiments, referring to FIGS. **2-4**, trigger **54** can be operably engaged with a closure drive system configured to translate both anvil **62** and channel **64** relative to outer sheath **57** of elongate shaft assembly **56**. Referring primarily to FIG. **4**, the closure drive can include cam **68** operably engaged with trigger **54** such that a first actuation of trigger **54** can rotate cam **68** about pin **70** and drive closure links **72** in a substantially linear direction. More particularly, trigger **54** can include lift pin **55** (FIG. **3**) extending therefrom which can be configured to contact surface **71** of cam **68** and lift cam **68** into the position illustrated in FIG. **8**. Cam **68** can further include cam slot **69** where, when cam **68** is rotated from its position illustrated in FIG. **4** to its position illustrated in FIG. **8**, the side walls of cam slot **69** can engage closure link pin **76** and, in the present embodiment, slide closure links **72** in a direction illustrated by arrow A (FIG. **4**).

Referring to FIGS. **2** and **4**, surgical instrument **50** can further include a spine assembly within elongate shaft assembly **56** (FIG. **1**), where the spine assembly can include proximal channel portion **78** and distal channel portion **80**. In various embodiments, channel portions **78** and **80** can be interconnected by the cooperative engagement of projection, or tongue, **84** and groove **86**. More particularly, referring to FIG. **2**, proximal channel portion **78** can include, in various embodiments, first half **77** and second half **79** which can be assembled to distal channel portion **80** such that projection **84** is secured within groove **86**. In at least one embodiment, proximal channel portion halves **77** and **79** can include projections **81** and/or apertures **83** configured to provide a snap-fit or press-fit engagement between proximal channel portion halves **77** and **79**. In various other embodiments, channel portions **78** and **80** can be interconnected by any suitable means and, in at least one embodiment, although not illustrated, portions **78** and **80** can be integrally formed. Similar to the above, referring to FIG. **2**, distal channel portion **80** can include distal end **88** which can be connected to staple cartridge channel **64**. More particularly, distal channel portion **80** and staple cartridge channel **64** can include cooperating tongue and groove features, for example, which can provide a press-fit or snap-fit interconnection therebetween, although any other suitable interconnection therebetween can be used.

Referring to FIG. **4**, proximal end **82** of channel portion **78** can be coupled to closure links **72** by pin **53** such that, when closures links **72** are translated by cam **68**, channel portion **78** is translated within elongate shaft assembly **56**. In at least one embodiment, channel portion **78** can further include projections **87** extending therefrom which can be configured to slide within recesses **85** (FIG. **3**) in housing portions **90** and substantially limit the translation of channel portion **78** along an axis. As staple cartridge channel **64** is connected to proximal channel portion **78** via distal channel portion **80**, channel **64**, and anvil **62** pivotably connected thereto, can be moved in direction A when cam **68** is rotated by trigger **54** as described above. In at least one embodiment, referring to FIG. **2**, proximal end **63** of anvil **62** can be configured to abut outer sheath **57** of elongate shaft assembly **56** when channel **64** and anvil **62** are translated relative to sheath **57**. After proximal end **63** of anvil **62** contacts outer sheath **57**, anvil **62** can be configured to rotate toward channel **64** and staple cartridge **66** in order to close anvil **62** as illustrated in FIG. **8**. In various embodiments, referring to FIG. **2**, channel **64** can include slots **65** therein which can be configured to guide anvil **62** as it is pivoted relative to channel **64**. Once anvil **62** is closed, the surgical instrument can further include a lock which holds anvil **62** in its closed position. In various embodiments, referring to FIGS. **9-11**, surgical instrument **50** can include spring lock **92** mounted to housing **90**, where spring lock **92** can be configured to releasably hold cam **68** in position which, as a result, locks closure links **72**, channel portions **78** and **80**, channel **64**, and anvil **62** in position until a surgeon desires to open anvil **62** as described in detail further below.

In various embodiments, after anvil **62** has been placed into its closed position, trigger **54** can be actuated a second time to operate a firing drive which advances cutting member **96** within end effector **58**. In at least one embodiment, the firing drive can be disengaged from trigger **54** prior to the first actuation of trigger **54**. In such embodiments, the first actuation of trigger **54** can operably engage trigger **54** with the firing drive and/or release a component of the firing drive such that the firing drive becomes operably engaged with trigger **54**. In the illustrated embodiment, referring to FIGS. **3** and **4**, the firing drive can include trigger gear portion **100** extending from trigger **54**, gear train **102**, gear carriage **130**, and rotatable drive shaft **106** which can be configured to advance cutting member **96** within end effector **58** as described in greater detail below. As illustrated in FIGS. **3-7**, gear train **102** can include ratchet gear **108**, main drive gear **110**, bevel drive gear **112**, and bevel gear **114** where, prior to the first actuation of trigger **54**, cam **68** can be configured to bias ratchet gear **108** out of engagement with main drive gear **110**. More particularly, referring to FIG. **3**, ratchet gear **108** can include shaft **116** and collar **118** where cam **68** can be configured to contact collar **118** and bias ratchet gear **108** away from main drive gear **112** such that ratchet face **109** on ratchet gear **108** is not engaged with ratchet face **111** on main drive gear **110**.

Upon the first actuation of trigger **54**, as described above, cam **68** can be rotated into the position illustrated in FIG. **8** and, as a result of such rotation, groove **120** (FIGS. **4** and **5**) in cam **68** can be configured to release ratchet gear **108**. More particularly, referring to FIGS. **5-7**, groove **120** can be dimensioned such that, when the rotation of cam **68** aligns groove **120** with collar **118**, collar **118** can slide past cam **68** and allow ratchet spring **122** to bias ratchet gear **108** into operative engagement with main drive gear **110**. Thereafter, trigger **54** can be released and then returned to its starting position by trigger spring **124** where trigger spring **124** can be connected to pin **126** extending from housing **90** and pin **128** extending from trigger **54**. Notably, even though trigger **54** can be returned to its starting position, cam **68** can remain locked in its second position by lock **92**, as described above, thereby maintaining the alignment between groove **120** and collar **118**. With ratchet gear **108** now operably engaged with drive gear **110**, a second actuation of trigger **54** can advance cutting member **96** and the staple driver within end effector **58**.

Referring primarily to FIGS. **3** and **4**, an actuation of trigger **54** can rotate trigger gear portion **100** about an axis defined by pin **70**. Trigger gear portion **100** can include gear teeth extending along the perimeter thereof which can, referring to FIGS. **5** and **6**, be engaged with gear teeth extending around the circumference, for example, of ratchet gear **108**. In use, as a result, the actuation, or rotation, of trigger **54** can rotate ratchet gear **108** about an axis defined by shaft **116** and pin **117** (FIG. **3**). As described above, ratchet gear **108** can, referring to FIGS. **5** and **6**, include ratchet face **109** which can be configured to engage ratchet face **111** of main drive gear **110**. In at least one embodiment, ratchet faces **109** and **111** can be configured to transmit the rotational motion of trigger **54** to main drive gear **110** upon the second actuation, or other subsequent actuation, of trigger **54** but also permit relative sliding movement therebetween when trigger **54** is released and returned to its unactuated position. In effect, ratchet faces **109** and **111** can be configured to transmit rotational motion to main drive gear **110** when ratchet gear **108** is rotated in one direction but not transmit rotational motion to main drive gear **110** when ratchet gear **108** is rotated in the opposite direction. Although a ratchet mechanism has been described and illustrated herein, any other suitable mechanism for transmitting motion between trigger **54** and main drive gear **110** can be used. Furthermore, although trigger **54** has been described and illustrated as a lever, any other suitable device can be used to motivate the firing and closing drives described herein.

Referring primarily to FIGS. **5-7**, main drive gear **110** can include gear teeth extending around the circumference thereof, for example, which can be engaged with gear teeth extending around the perimeter, for example, of bevel drive gear **112**. In use, as a result, the rotational motion transmitted to main drive gear **110** from ratchet gear **108**, for example, can be transmitted to bevel drive gear **112**. In various embodiments, bevel drive gear **112** can be mounted to or integrally formed with shaft **113**, where shaft **113** can define an axis about which bevel drive gear **112** can be rotated. In at least one embodiment, referring to FIG. **3**, surgical instrument **50** can further include bracket **115** about which bevel drive gear **112** and shaft **113** can be rotated. As described in greater detail below, bracket **115** can also include supports **119** which can be configured to slidably support at least a portion of gear carriage **130**. In various embodiments, referring to FIGS. **5-7**, bevel gear **114** can be attached to bevel drive gear **112** or, alternatively, bevel gear **114** can be mounted to or integrally formed with shaft **113**. In either event, the rotational motion transmitted to bevel drive gear **112** can be transmitted to bevel gear **114**.

In various embodiments, although not illustrated, bevel gear **114** could be directly engaged with drive shaft **106** via cooperating bevel gear teeth. In at least one such embodiment, bevel gear **114** could rotate drive shaft **106** in a clockwise direction, for example, and advance cutting member **96** within end effector **58** as described below. In such embodiments, the actuation of trigger **54** could advance cutting member **96** within end effector **58**, however, cutting member **96** would have to be retracted either manually or via an additional retraction system. In the illustrated embodiment of the present invention, referring to FIGS. **3** and **5-7**, surgical instrument **50** can further include a switching mechanism which can allow drive shaft **106** to be rotated in either a clockwise or counter-clockwise direction and, correspondingly, allow cutting member **96** to be advanced or retracted via the actuation of trigger **54**. In various embodiments, referring primarily to FIGS. **5** and **6**, the switching mechanism can include gear carriage **130** which can be shifted between a first position in which the rotational motion of bevel gear **114** rotates drive shaft **106** in a clockwise direction, for example, and a second position in which the rotational motion of bevel gear **114** rotates drive shaft **106** in a counter-clockwise direction.

In various embodiments, referring to FIGS. **5-7**, gear carriage **130** can include housing **132**, forward gear **134**, and reversing gear **136** where forward gear **134** and reversing gear **136** can be rotatably mounted to housing **132**. In at least one embodiment, drive shaft **106** can include substantially hex-shaped end **107**, for example, which can be received within apertures (not illustrated) in forward gear **134** and reversing gear **136** such that gears **134** and **134** are rotatably engaged with drive shaft **106**. In other various embodiments, end **107** can include any other suitable shape or configuration such that gears **134** and **136** are rotatably engaged with drive shaft **106**. In either event, referring to FIG. **5**, gear carriage **130** can be slid along end **107** such that either forward gear **134** or reversing gear **136** can be engaged with bevel gear **114**. In use, when forward gear **134** is engaged with bevel gear **114**, for example, the rotational motion of bevel gear **114** can be transmitted to forward gear **134** and, owing to cooperating geometries of end **107** and the aperture in forward gear **134**, the rotational motion of gear **134** can be transmitted to drive shaft **106**. In order to rotate drive shaft in the opposite direction, gear carriage **130** can be slid proximally, or rearward, such that reversing gear **136** engages bevel gear **114**. A mechanism for motivating gear carriage **130** in this manner is described further below.

In various embodiments, when forward gear **134** is engaged with bevel gear **114**, as illustrated in FIG. **5**, reversing gear **136** can be disengaged from bevel gear **114** such that reversing gear **136** is free to rotate with drive shaft **106**. In at least one embodiment, gear carriage **130** can further include spacer **135** which can be configured to rotatably support and align gears **134** and **136** yet permit gears **134** and **136** to rotate independent of one another. In some embodiments, gear carriage **130** can be placed in a position intermediate the forward and rearward positions such that both gears **134** and **136** engage bevel gear **114** and hold drive shaft **106** in a 'locked-out' condition such that trigger **54** cannot be actuated. In other various embodiments, gear carriage **130** can be placed in an intermediate position such that neither gears **134** and **136** engage bevel gear **114**. In such embodiments, the firing drive is in a 'free' condition and the rotational motion of bevel gear **114** is not transmitted to drive shaft **106**.

In various embodiments, referring primarily to FIG. **2**, drive shaft **106** can further include threaded drive portion **138** which can be operably engaged with firing nut **140**. In at least one embodiment, threaded drive portion **138** can be configured to slidably advance and/or retract firing nut **140** in response to rotational motion of drive shaft **106**. More particularly, firing nut **140** can include threaded aperture **141** which can be configured to threadably receive threaded drive portion **138** such that the rotation of drive shaft **106** produces a reactional force which advances firing nut **140** distally. In at least one embodiment, firing nut **140** can include projection **142** extending therefrom which can be configured to extend through a slot defined between proximal channel portion halves **77** and **79** in order to constrain the movement of firing nut **140** along an axis. In effect, the slot can prevent firing nut **140** from rotating with drive shaft **106** and can define a path for projection **142** as firing nut **140** is translated within channel portion **78**.

In various embodiments, referring to FIG. **2**, cutting member **96** can be operably engaged with firing nut **140** such that the translation of firing nut **140**, as described above, can result in the translation of cutting member **96** within end effector **58**. In at least one embodiment, surgical instrument **50** can further include firing rod **144** connected to firing nut **140**, drive bar **146** connected to cutting member **96**, and adapter **148** configured to connect drive bar **146** to firing rod **144**. In various embodiments, firing rod **144** can include proximal end **145** which can include an aperture configured to receive at least a portion of firing nut **140** in a press-fit manner. In at least one embodiment, proximal end **145** of firing rod **144** can include deformable member **147** which can be configured to engage recess **143** in firing nut **140** after deformable member **147** has been depressed or deformed inwardly toward recess **143**. In either event, firing rod **144** can further include distal end **149** which can be configured to receive plug **150** in a press-fit manner, for example, where plug **150** can include projection **152** extending therefrom which can be received within slot **154** in adapter **148**. In various embodiments, adapter **148** can further include slot **151**, where slot **151** can be configured to receive connector tab **154** of drive bar **146** such that, when adapter **148** is translated by firing rod **144**, drive bar **146** can be translated within distal retainer section **80**. In at least one embodiment, drive bar **146** can further include distal end **156** which can be configured to engage recess **97** in cutting member **96** and advance and/or retract cutting member **96** within end effector **58**. As described above, cutting member **96** can include knife **99** which can be configured to incise tissue positioned between anvil **62** and staple cartridge **66** as cutting member **96** is advanced within end effector **58**. Further, as described above, cutting member **96** can include portion **95**, where portion **95** can be configured to push a staple driver (not illustrated) within staple cartridge **66** to deploy staples (not illustrated) removably stored therein.

In various embodiments, the surgical instrument can be configured to advance cutting member **96** a desired distance upon a single actuation of trigger **54**, i.e., the second overall actuation of trigger **54** in embodiments where the first actuation of trigger **54** closes anvil **62** as described above. In other embodiments, however, more than one actuation of trigger **54** can be used to advance cutting member **96** a desired distance. In at least one such embodiment, referring to FIGS. **12-16**, trigger **54** can be actuated three times to advance cutting member **96** from proximal end **59** to distal end **61** of end effector **58**. The quantity of such actuations in other embodiments, however, will depend largely upon the overall distance that cutting member **96** is to be displaced and the displacement of cutting member **96** as a result of each actuation. Notably, prior to the second actuation of trigger **54**, cutting member **96** can be positioned in proximal end **59** of end effector **58** and firing nut **140** can be positioned in its most proximal position. Upon the second actuation of trigger **54**, referring to FIGS. **13** and **14**, cutting member **96** can be advanced approximately one-third of the distance between proximal end **59** and distal end **61** and, similarly, firing nut **140** can be advanced distally along drive shaft **106**. Thereafter, referring to FIG. **15**, cutting member can be advanced an additional one-third of the distance between proximal end **59** and distal end **61** upon the third actuation of trigger **54** and, similarly, referring to FIG. **16**, cutting member **96** can be advanced into distal end **61** of end effector **58** upon the fourth actuation of trigger **54**.

In various embodiments, in order to assist a surgeon in monitoring the amount of times that trigger **54** has been actuated, surgical instrument **50** can include a counting mechanism which can be configured to display the amount of times that trigger **54** has been actuated and/or the amount of actuations remaining to deploy all of the staples in the staple cartridge. In either event, referring primarily to FIGS. **3** and **9**, one embodiment of counting mechanism **170** can include indicator nut **172**, indicator plate **174**, and indictor window **171** (FIG. **1**) in housing **90**. In at least one embodiment, indicator plate **174** can include indicia thereon which can communicate to the surgeon the amount of times that trigger **54** has been actuated to advance cutting member **96**. In such embodiments, indicator plate **174** can include blank portion **173** which is visible through window **171** before and after the first actuation of trigger **54**, i.e., the actuation of trigger **54** which closes anvil **62** as described above. Upon the second actuation of trigger **54**, the rotation of drive shaft **106** can advance indicator nut **172** and indicator plate **174**, which is mounted to indicator nut **172**, distally such that the numeral "1" or other appropriate indicia on indicator plate **174** can be seen through indicator window **171**. Accordingly, such an indicium can indicate to the surgeon that cutting member **96** has been advanced by one actuation of trigger **54**. Similar to firing nut **140**, indicator nut **172** can include a threaded aperture which can be threadably engaged with threaded portion **176** of drive shaft **106** such that the rotation of drive shaft **106** applies a reactional force to indicator nut **172** and advances it distally. Subsequent actuations of trigger **54** can move the numerals '2' and '3' beneath indicator window **171**.

In order to retract cutting member **96**, as outlined above, gear carriage **130** can be shifted such that forward gear **134** is disengaged from bevel gear **114** and, referring to FIGS. **17** and **18**, reversing gear **136** is engaged with bevel gear **114**. Thereafter, subsequent actuations of trigger **54** can rotate drive shaft **106** in the opposite direction and translate firing nut **140** proximally. More particularly, owing to the threaded engagement between firing nut **140** and threaded portion **138** of drive shaft **106**, the rotation of shaft **106** in the opposite direction applies a reactional force to firing nut **140** which displaces firing nut **140** in the proximal direction. Accordingly, firing rod **144**, drive bar **146** and cutting member **96**, which can be connected to firing nut **140** as described above, are also displaced in the proximal direction thereby retracting cutting member **96** within end effector **58**. Similarly, the rotation of shaft **106** in the opposite direction can displace indictor nut **172** of indicator assembly **170** proximally as well. More particularly, the first actuation of trigger **54** after gear carriage **130** has been shifted, i.e., the fifth overall actuation of trigger **54**, can cause drive shaft **106** to apply a reactional force to indicator nut **172** and move nut **172** proximally. In such circumstances, indicator nut **172** can move indicator plate **174** relative to window **171** such that the numeral '2' is visible through indicator window **171** which can remind the surgeon that two more actuations of trigger **54** are required to fully retract cutting member **96**.

Although trigger **54** is actuated three times to advance and/or retract cutting member **96** in the present embodiment, the actuations required to advance cutting member **96** can be different than the actuations required to retract cutting member **96** in other embodiments. Exemplary embodiments including features for advancing and retracting cutting member **96** at different rates are described in detail further below. Furthermore, in at least one embodiment, portion **95** of cutting member **96** can be engaged with the staple driver such the retraction of cutting member **96** also retracts the staple driver. In other embodiments, however, the staple driver can be left behind in the staple cartridge and only the cutting member **96** is retracted. Such embodiments may be utilized where a spent staple cartridge assembly is replaced with a new staple cartridge assembly which includes its own staple driver therein and, as a result, it may be desirable to leave the used staple driver in the spent cartridge.

In order to motivate gear carriage **130** as described above, surgical instrument **50** can include, referring to FIGS. **3-5**, switching mechanism **160**. In at least one embodiment, switching mechanism **160** can include shaft switch **162**, shifter handles **164** extending therefrom, and shifter link **166**, where shifter link **166** can be connected to shaft **162** via shifter pin **169** and gear carriage housing **132** via pin **168**. In order to slide gear carriage **130** relative to drive shaft **106** as described above, shifter handles **164** can be configured to rotate shaft **162** such that crank arm **163** extending from shaft **162** displaces shifter link **166** and drives gear carriage **130** along axis **105** of drive shaft **106**. In the illustrated embodiment, when shifter handles **164** are oriented in a substantially downward direction, as illustrated in FIG. **8**, crank arm **163** is oriented in a substantially upward direction. In this configuration, referring to FIG. **5**, gear carriage **130** is positioned in its most rearward, or proximal, position such that forward gear **134** is operably engaged with bevel gear **114**. In order to shift surgical instrument **50** into a configuration in which cutting member **96** is retracted, shifter handles **164** can be rotated upwardly, as illustrated in FIG. **17**, to rotate crank arm **163** forward, or distally. Correspondingly, crank arm **163** can be configured to displace link arm **166** distally and pull gear carriage **130** into its most distal position, thereby engaging reversing gear **136** with bevel gear **114**. In the event that the surgeon desires to advance cutting member **96** after at least partially retracting cutting member **96**, the surgeon can rotate shifter handles **164** downwardly and re-engage forward gear **134** with bevel gear **114**.

In various embodiments, referring to FIGS. **3** and **5**, surgical instrument **50** can further include a bistable compliant mechanism for biasing switching mechanism **160** into a configuration where one of gears **134** or **136** is engaged with bevel gear **114**. Stated another way, the bistable compliant mechanism can cause switching mechanism **160** to become dynamically unstable when a surgeon only partially rotates shifter handles **164**. In such circumstances, the bistable compliant mechanism can bias switching mechanism **160** into one of two configurations where it is stable, i.e., the forward and reversing configurations. In various embodiments, bistable compliant mechanism **180**, referring primarily to FIG. **3**, can include receiver **182**, spring **184**, plunger **186** and toggle pin **188**. In at least one embodiment, toggle pin **188** can connect plunger **186** to switch shaft **162** and receiver **182** can be connected to projection **183** extending from housing **90**. In use, spring **184** can be configured to apply a biasing force to shaft **162** via plunger **186** and can be configured to rotate shaft **162** in the event that shaft **162** is only partially rotated between its forward and reversing orientations.

In various embodiments, once cutting member **96** has been fully retracted, the end effector closing system and the staple firing system can be reset so that the spent staple cartridge can be removed from surgical instrument **50**, a new staple cartridge **66** can be positioned within staple cartridge channel **64**, and surgical instrument **50** can be used to further staple and cut tissue as described above. In the illustrated embodiment, cam **68** can be released from lock **92** to open anvil **62** and reset the end effector closure system. Similarly, ratchet gear **108** can be disengaged from main drive gear **110** to disengage trigger **54** from gear train **102** and reset the staple firing system. In at least one embodiment, cam **68** and ratchet gear **108** can be manually reset, however, referring primarily to FIGS. **3-5**, **9**, **10**, **19** and **20**, surgical instrument **50** can include a reset system which can automatically reset the end effector closure system and staple firing system described above. In various embodiments, the final return actuation of trigger **54** can reset these systems as described in detail below.

As outlined above, the first actuation of trigger **54** can rotate cam **68** into the position illustrated in FIG. **8** and spring lock **92** can be configured to hold cam **68** in place as the firing drive is operated by subsequent actuations of trigger **54**. As also illustrated in FIG. **8**, surgical instrument **50** can further include cam spring **67** which can be configured to bias cam **68** downwardly and, referring to FIGS. **9** and **10**, hold cam lock arm **73** extending from cam **68** against spring lock **92**. In such embodiments, cam lock arm **73** can include recess **74** which can be configured to receive at least a portion of spring lock **92**. In order to assist cam spring **67** in keeping cam **68** from lifting upwardly during subsequent actuations of trigger **54** and becoming disengaged from cam spring **92**, indicator nut **174** can be configured to contact cam rail **75** and hold cam lock arm **73** against spring lock **92**. More particularly, as indicator nut **174** is advanced distally, as described above, indicator nut **174** can be slid along contact rail **75** providing a positive stop against which cam **68** cannot rotate. Once indicator nut **174** is returned to its most proximal position, however, indicator nut **174** can become aligned with ramp **89** and, as a result, the third return actuation of trigger **54** can cause cam **68** to rotate upward slightly, thereby disengaging lock arm **73** from spring lock **92** as illustrated in FIG. **10**.

After cam **68** has been released from lock **92**, cam return spring **67** can be configured to rotate cam **68** downwardly and return it to its original position. As cam **68** is rotated downwardly, the walls of cam slot **69** can be configured to drive closure links **72** distally and, correspondingly, drive channel portions **78** and **80** and staple cartridge channel **64** distally as well. In at least one embodiment, end effector **58** can further include a spring (not illustrated) configured to bias anvil **62** upwardly as staple cartridge channel **64** is slid distally, i.e., away from outer sheath **57** of elongate shaft assembly **56**. In other various embodiments, although not illustrated, surgical instrument **50** can further include an actuator in which a surgeon can operate to pull or push anvil **62** into an open position. In either event, in at least one embodiment, cam return spring **67** can assert a force sufficient for cam **68** to displace ratchet gear **108** out of engagement with main drive gear **110** and, as a result, reset the firing drive. In other various embodiments, cam return spring **67** may not be strong enough to pull cam **68** downwardly with sufficient force to disengage ratchet gear **108** from main drive gear **110**. In at least one such embodiment, surgical instrument **50** can further include, referring to FIGS. **3-5** and **19**, a toggle switch assembly which can selectively bias ratchet gear **108** away from main drive gear **110**.

In various embodiments, referring primarily to FIGS. **3**, **4**, and **9**, toggle switch assembly **190** can include toggle actuator **192** mounted to drive shaft **106**, where toggle actuator **192** can include toggle arm **193** extending therefrom. Upon the final return actuation of trigger **54**, in at least one embodiment, indicator nut **172** can contact toggle actuator **192** and rotate it about drive shaft **106** such that toggle arm **193** is rotated toward ratchet gear **108**. In at least one such embodiment, referring to FIG. **9**, indicator nut **172** can further include ramp **179** which can be configured to engage projection **191** extending from toggle actuator **192** and rotate toggle actuator **192** clockwise about drive shaft **106**. In various embodiments, toggle arm **193** can be configured to contact ratchet gear **108** as it is rotated about drive shaft **106** and displace ratchet gear **108** away from main drive gear **110**. In at least one embodiment, ratchet gear **108** can be sufficiently displaced away from drive gear **110** to allow cam return spring **67** to position cam **68** adjacent collar **118**. Thereafter, cam **68** can hold ratchet gear **108** in this position until cam **68** is rotated upwardly as described above.

Although the above-described mechanisms can reset cam **68** and ratchet gear **108** into their initial positions, toggle arm **193** of toggle actuator **192**, at least in the illustrated embodiment, can remain positioned against collar **118** of ratchet gear **108**. Accordingly, even if cam **68** is rotated upwardly such that groove **120** is aligned with collar **118** upon the first actuation of trigger **54**, ratchet gear **108** may not be released to engage main drive gear **110** as described above. In view of this, in at least one embodiment, surgical instrument **50** can include a reset mechanism for rotating toggle arm **193** out of engagement with ratchet gear **108**. Such a mechanism can, in various embodiments, be manually operated and/or automatically operated in response to an actuation of trigger **54**, for example. In at least one embodiment, as illustrated in FIG. **20**, housing **90** can include projection **91** extending therefrom which can be configured to rotate toggle actuator **192** about drive shaft **106** and return it to its original, unactuated position as illustrated in FIG. **9**. More particularly, in various embodiments, projection **91** can be configured to engage toggle link **194** (FIG. **3**) as gear carriage **130** is moved from its distal position in which reversing gear **136** is engaged with bevel gear **114** to its proximal position in which forward gear **134** is engaged with bevel gear **114**. Such movement can be effected by switching mechanism **160** when shifter handles **164** are rotated downwardly to move gear carriage **130** proximally and place surgical instrument **50** in its 'advancing' configuration described above. As a result of the contact between toggle link **194** and projection **91**, toggle link **194** can be rotated about pin **195** such that toggle link **194** contacts actuator arm **193** and rotates toggle actuator **192** counterclockwise about drive shaft **106**. In various embodiments, toggle switch assembly **190** can further include bistable compliant mechanism **196**, which can assist in assuring that toggle switch assembly **190** does not become stuck in an intermediate configuration.

As described above, surgical instruments in accordance with the present invention can include a single trigger for actuating both an end effector closure system and a staple firing system. While the above-described features were described in connection with such single trigger surgical instruments, several of the features described above can be used in surgical instruments having a first trigger for actuating an end effector closure system and a second trigger for actuating a staple firing system. Referring to FIGS. **23-30**, for example, surgical instrument **200** can include trigger **201** for actuating an end effector closure system and trigger **204** for actuating a staple firing system. In various embodiments, referring to FIG. **25**, the end effector closure system can include closure link **203** operably engaged with closure trigger **201** via pin **209**. The end effector closure system can further include slider **205** and closure tube **207** (FIG. **23**), where closure tube **207** can be operably connected to closure link **203** via slider **205** and pin **211**. More particularly, referring to FIG. **29**, closure tube **207** can include flange **213** at its most proximal end which can be configured to be received within slot **215** in slider **205** such that the sliding motion of slider **205** is transmitted to closure tube **207**.

In use, referring primarily to FIGS. **29** and **30**, the actuation of trigger **201** can translate closure link **203** distally and, correspondingly, translate slider **205** and closure tube **207** distally as well. In various embodiments, closure tube **207** can include features which are cooperatively engaged with anvil **62** such that translation of closure tube **207** causes anvil **62** to rotate toward staple cartridge channel **64**. More particularly, referring to FIG. **24**, anvil **62** can include projection **51** extending therefrom which can be received within aperture **217** of closure tube **207** such that sidewalls of aperture **217** can abut projection **51** and rotate anvil **62** downwardly. To guide anvil **62**, as outlined above, staple cartridge channel **64** can include slots **65** which can define a path for anvil **62** as it is rotated. Surgical instrument **200** can further include lock **219** which can be configured to hold trigger **201** in an actuated position thereby holding anvil **62** in a closed position. To open anvil **62**, lock **219** (FIG. **28**) can be disengaged from trigger **201** such that trigger **201** can be returned to its unactuated position. As trigger **201** is returned to its unactuated position, trigger **201** can drive slider **205** and closure tube **207** proximally and, owing to the operative engagement between projection **51** and aperture **217**, rotate anvil **62** upwardly.

As indicated above, surgical instruments in accordance with the present invention can include a firing drive which can be configured to advance a cutting member, for example, at a first rate and retract the cutting member at a different rate. In various embodiments, referring to FIGS. **23-30**, surgical instrument **200** can include firing drive **202** which can comprise trigger **204**, drive shaft **206**, first ratchet assembly **210**, and second ratchet assembly **212**. In at least one embodiment, ratchet assemblies **210** and **212** can be configured to rotate drive shaft **206** in clockwise and counter-clockwise directions, respectively, in order to advance or retract cutting member **96** within end effector **58**. In various embodiments, referring to FIG. **25**, trigger **204** can be selectively engageable with ratchet assemblies **210** and **212** such that, when trigger **204** is actuated, only one of ratchet assemblies **210** and **212** is driven by trigger **204**. In at least one such embodiment, trigger **204** can be slidable along pin **214** in order to engage trigger **204** with one of ratchet assemblies **210** and **212**. In the illustrated embodiment, pin **214** can be rotatably received in apertures **216** in housing portions **218** and provide an axis of rotation for trigger **204**.

In various embodiments, referring to FIG. **27**, trigger **204** can be positioned such that pawl **220**, which can be pivotably mounted to trigger **204**, is engaged with ratchet wheel **222** and, upon the actuation of trigger **204**, ratchet wheel **222** is rotated about pin **214** by pawl **220**. Upon the release of trigger **204**, pawl **220** can slide over ratchet teeth **224** of ratchet wheel **222** permitting relative movement therebetween. In at least one embodiment, ratchet assembly **210** can further include a pawl spring (not illustrated) configured to bias pawl **220** into engagement with ratchet teeth **224** and re-engage pawl **220** with ratchet teeth **224** when trigger **204** is reactuated. In order to transmit the rotation of ratchet wheel **222** to drive shaft **206**, drive shaft **206** can include forward gear **226** connected thereto. More particularly, in at least one embodiment, ratchet wheel **222** can further include gear teeth **228** which can be operably engaged with forward gear **226** such that the rotation of ratchet wheel **222** rotates forward gear **226** and drive shaft **206** about axis **230** (FIG. **25**). In various embodiments, forward gear **226** can be press-fit, for example, onto drive shaft **206** or, in other various embodiments, forward gear **226** can be integrally formed with drive shaft **206**.

In various embodiments, similar to the surgical instruments described above, drive shaft **206** can, referring to FIG. **24**, be operably engaged with firing nut **140** in order to translate firing nut **140** within proximal retainer portion **232**. As also described above, the translation of firing nut **140** can be transmitted to cutting member **96** via drive bar **146** in order to advance cutting member **96** within end effector **58**. In order to retract cutting member **96** within end effector **58**, in at least one embodiment, trigger **204** can be slid into engagement with second ratchet assembly **212** such that drive shaft **206** is rotated in the opposite direction when trigger **204** is actuated. Similar to ratchet assembly **210**, referring to FIG. **28**, ratchet assembly **212** can include ratchet wheel **234** and pawl **236** where pawl **236** can be pivotably mounted to trigger **204** and can be operatively engaged with ratchet wheel **234** via ratchet teeth **238**. Similar to ratchet wheel **222**, ratchet wheel **234** can include gear teeth **240** which can be operably engaged with reversing gear **242** mounted to drive shaft **206**. As ratchet wheels **222** and **234** engage drive shaft **206** on substantially opposite sides, ratchet wheels **222** and **234** can rotate drive shaft **206** in opposite directions, i.e. clockwise and counter-clockwise directions, respectively. Thus, in order to select whether cutting member **96** is advanced or retracted within end effector **58**, trigger **204** can be slid into operative engagement with either first ratchet assembly **210** or second ratchet assembly **212**.

In various embodiments, although not illustrated, first ratchet wheel **222** and second ratchet wheel **234** can have substantially the same diameter, or pitch radius. Stated another way, the distance between the center, or axis of rotation, of the ratchet wheels and the gear teeth of the ratchet wheels can be the same. In such embodiments, the distance that cutting member **96** is advanced per actuation of trigger **204** will be substantially the same distance that cutting member **96** is retracted per actuation of trigger **204**. While suitable in some circumstances, such embodiments may require a surgeon to actuate trigger **204** several times before cutting member **96** is completely retracted. In view of the above, in various embodiments, first ratchet wheel **222** can have a pitch radius which is different than the pitch radius of second ratchet wheel **234**. In at least one embodiment, second ratchet wheel **234** can have a larger pitch radius than first ratchet wheel **222** such that cutting member **96** is retracted a distance per actuation of trigger **204** which is greater than the distance that cutting member **96** is advanced per actuation of trigger **204**. Stated another way, second ratchet assembly **212** can, at least in these embodiments, retract cutting member **96** at a rate which is greater than which it is advanced. In such embodiments, first ratchet assembly **210** can, owing to the slower advancing rate, provide a greater torque or advancing force to cutting member **96** while second ratchet assembly

212 can, owing to the faster retracting rate, reduce the time required for the surgeon to retract the cutting member.

While the term 'rate', as used above, is used to describe the distance that cutting member 96 can be advanced or retracted per actuation of trigger 204, the term 'rate' is not so limited. In at least one embodiment, the term 'rate' can be used to describe the velocity and/or acceleration in which the cutting member is moved. In such embodiments, it may be desirable to have a cutting member which is advanced at a lower velocity and/or acceleration to better control the cutting member and retracted at a greater velocity and/or acceleration to reduce the time required to retract the cutting member. Furthermore, while the illustrated embodiments include ratchet assemblies for providing the different advancing and retracting rates, the invention is not so limited. On the contrary, other embodiments are envisioned which include spur gear trains, bevel gears, and/or other motion transmission devices.

In various embodiments, surgical instruments in accordance with the present invention may include a gearbox for increasing or decreasing the rotational speed of the drive shaft. In at least one embodiment, referring to FIG. 25, surgical instrument 200 can further include gearbox 250 which can be operably positioned intermediate drive shaft 206 and ratchet assemblies 210 and 212. In various embodiments, gearbox 250 can be used to 'gear down' the speed of drive shaft 206 such that shaft 206 turns at a slower speed than if gearbox 250 were not utilized. In alternative embodiments, a gearbox can be used to 'gear up' the speed of drive shaft 206 such that drive shaft 206 turns at a faster speed. In at least one embodiment, gearbox 250 can include at least one set of planetary gears for changing the speed of drive shaft 206. In other various embodiments, a gearbox, such as gearbox 252 illustrated in FIGS. 21 and 22, can include housing 253, input gear 254 mounted to input shaft 256, pinion gears 258, and output gear 260 mounted to output shaft 262. In such embodiments, owing to the different pitch radii of input gear 254 and output gear 260, input shaft 256 and output shaft 262 will rotate at different speeds. To facilitate the rotational movement of gears 254, 258, and 260 within housing 253, gearbox 252 can further include various support plates 264, spacers 266, and pins 268 as illustrated in FIG. 22. In addition to the above, gearbox 252 can also be used to convert the clockwise motion of input shaft 256, for example, into counter-clockwise motion of output shaft 262.

In various embodiments described above, trigger 204 of surgical instrument 200 can be slid between a first position in which it is operatively engaged with first ratchet assembly 210 and a second position in which it is operatively engaged with second ratchet assembly 212. In at least one embodiment, firing drive 202 can be configured such that first pawl 220, for example, is disengaged from first ratchet wheel 222 before second pawl 236 is engaged with second ratchet wheel 234. In such embodiments, trigger 204 may be positioned in an intermediate position where it is not operably engaged with either first ratchet assembly 210 or second ratchet assembly 212. In various embodiments, as a result, firing drive 202 can be in a 'free' state where the actuation of trigger 204 does not result in the rotation of drive shaft 206. In alternative embodiments, firing drive 202 can be configured such that second pawl 236, for example, is engaged with second ratchet wheel 234 before first pawl 220 is operatively disengaged from first ratchet wheel 222. In such embodiments, trigger 204 may be positioned in an intermediate 'locked' state where trigger 204 cannot be actuated, thereby indicating to the surgeon that trigger 204 is not completely engaged with either one of the ratchet assemblies and trigger 204 requires further adjustment.

In various embodiments, surgical instrument 200 can include a device which biases trigger 204 into engagement with one of first ratchet assembly 210 and second ratchet assembly 212. In at least one embodiment, referring to FIG. 33, surgical instrument 200 can further include bistable compliant mechanism 270 which can bias trigger 204 out of an intermediate position described above and into engagement with either first ratchet assembly 210 and second ratchet assembly 212. In various embodiments, bistable compliant mechanism 270 can include spring 272 and link 274, where spring 272 can apply a biasing force to trigger 204 via link 274 such that the biasing force acts to move trigger 204 out of its intermediate position illustrated in FIG. 33 and into engagement with either first ratchet wheel 222 or second ratchet wheel 234. More particularly, when trigger 204 is positioned in its intermediate position, spring 272 can be stretched to a length X1 and, owing to the resiliency of spring 272, spring 272 can seek to shorten itself to its unstretched length, or at least a length shorter than X1, such as length X2 for example. In order for spring 272 to shorten itself to length X2, spring 272 can rotate link 274 about pin 275 where pin 275 can extend from and pivotably mount link 274 to surgical instrument housing 218. More particularly, as the first end of spring 272 is mounted to pin 276 extending from housing 218 and the second end of spring 272 is mounted to pin 277 extending from link 274, spring 272 can shorten itself by moving pin 277 closer to pin 276 which is most easily accomplished by rotating link 274 about pin 275. As link 274 is rotated about pin 275, the side walls of slot 278 in link 274 can be configured to engage pin 279 extending from trigger 204 and slide trigger 204 into engagement with first ratchet wheel 222 or second ratchet wheel 234. In effect, the intermediate position of trigger 204 illustrated in FIG. 33 represents a dynamically unstable position and the positions of trigger 204 where trigger 204 is engaged with ratchet wheels 222 and 234 represent the dynamically stable positions of the firing drive system.

In various embodiments, as described above, surgical instruments in accordance with the present invention can include devices for rotating a drive shaft in a first direction in which the drive shaft advances a cutting member within an end effector, for example, and a second direction in which the drive shaft retracts the cutting member. In at least one embodiment, referring to FIGS. 31 and 32, a surgical instrument can include transmission 280, for example, which can allow a surgeon to select whether the drive shaft advances or retracts the cutting member. In various embodiments, transmission 280 can include housing 282, internal input shaft 284, external input shaft 285, output drive shaft 286, and switching mechanism 288, where switching mechanism 288 can be configured to selectively engage internal input shaft 284 and external input shaft 285 with output shaft 286. Although not illustrated, the surgical instrument can further include a trigger, for example, which is operatively engaged with external drive shaft 285 in order to rotate drive shaft 285 about axis 287 in a clockwise direction, for example. In at least one embodiment, transmission 280 can include pinion gears 292 rotatably mounted within housing 282, input gear 293 fixedly mounted to external input shaft 285, and output gear 294 mounted to output drive shaft 286, where input gear 293 can be operably engaged with outer gear teeth 290 of pinion gears 292 such that the rotation of external shaft 285 is transmitted to pinion gears 292.

In a first configuration of transmission 280, output gear 294 can be operatively engaged with inner gear teeth 291 of pinion gears 292 such that the rotation of pinion gears 292 is transmitted to output drive shaft 286. More particularly, output gear **294** can be operably engaged with output drive shaft **286** via splined end **296** such that output gear **294** drives output drive shaft **286** about axis **287**. In this first configuration, a clockwise rotation of external input shaft **285**, for example, can be converted into a counter-clockwise motion of output drive shaft **286**. In a second configuration of transmission **280**, output gear **294** can be disengaged from pinion gears **292** such that the rotation of external input shaft **285** is not transmitted to output drive shaft **286** via pinion gears **292**. In order to disengage output gear **294** from pinion gears **292**, internal drive shaft **284** can be slid relative to external drive shaft **285** such that input gear **297** contacts recess **298** in output gear **294** and pushes output gear **294** away from pinion gears **292**. In at least one embodiment, recess **298** can include teeth **299** which can be operatively engaged with input gear **297** of internal input shaft **284** such that the rotation of internal input shaft **284** is transmitted to output drive shaft **286**. In this second configuration of transmission **280**, a clockwise rotation of internal input shaft **284** can be directly transmitted to output drive shaft **286** such that output shaft **286** rotates in a clockwise direction as well. In order to reengage output gear **294** with pinion gears **292**, internal input gear **284** can be disengaged from output gear **294** to allow spring **281** to slide output gear **294** along splined end **296**.

In the embodiments described above, a surgeon can selectively move internal input shaft **284** relative to external input shaft **285** to place transmission **280** in either a forward or reversing configuration. In order to move input shaft **284**, in various embodiments, the surgical instrument can further include an actuator or trigger configured to translate internal input shaft **284**. In at least one embodiment, the surgical instrument can include a first actuator or trigger for rotating external input shaft **285** and a second actuator or trigger for translating internal shaft **284** relative to external shaft **285**. In such embodiments, internal input shaft **284** can include splines **283** which can be slidably engaged with external input shaft **285** such that the rotation of external shaft **285** is transmitted to internal shaft **284** yet sliding motion is permitted therebetween. In at least one embodiment, transmission **280** can further include bearing **300** which can rotatably support input gear **293** and, when compressed between input gear **293** and housing **282**, provide a biasing force to keep input gear **293** operably engaged with pinion gears **292**. In various embodiments, output shaft **286** can include member **302** extending therefrom which can be configured to be received within recess **301** of housing **282** in order to reduce, or even eliminate, relative movement between output shaft **286** and housing **282**. In at least one embodiment, although not illustrated, transmission **280** may only have one pinion gear **292** and still operate in the manner described above.

In various embodiments, transmission **280** can also be configured to advance cutting member **96**, for example, at a different rate than which it is retracted. In at least one embodiment, referring to FIGS. **31** and **32**, the operative engagement between internal input shaft **284** and output shaft **286** can be used to advance cutting member **96** and, owing to the direct engagement between input gear **297** and output gear **294**, internal input shaft **284** and output shaft **286** can rotate in a 1:1 ratio, i.e., for every rotation of internal input shaft **284**, output shaft **286** is rotated once. In various embodiments, the operative engagement between external input shaft **285** and output shaft **286** can be used to retract cutting member **96** and, owing to the different pitch radii of input gear **293** and output gear **294** and their operative engagement with pinions **292**, external input shaft **285** and output shaft **286** can rotate in a ratio different than 1:1. In the illustrated embodiment, output shaft **286** can rotate at a faster speed than external input shaft **285** when they are mated via pinions **292**. In various embodiments, as a result, cutting member **96** can be translated at a faster rate when external input shaft **285** is operably engaged with output shaft **286** than when internal input shaft **284** is operably engaged with output shaft **286**.

The above described invention also has applicability to robotic surgical systems. Such systems are well known in the art and include those available from Intuitive Surgical, Inc., Sunnyvale, Calif. Examples are also disclosed in U.S. Pat. Nos. 6,783,524; 7,524,320; and 7,824,401. All of which are hereby incorporated herein by reference.

Generally, robotic surgical systems have a remotely controllable user interface and a remotely controllable arm which are configured to interface with and operate surgical instruments and systems. The arms are controllable with an electronic control system(s) that is typically adapted to a localized console for user to interface with. The instruments can be powered either locally by the surgical system or have isolated powered systems from the overall robotic control.

The robotic surgical system includes an actuation assembly, a monitor, a robot, and at least one reliably attached loading unit attached to the robot arm having at least one surgical instrument to perform at least one surgical task and configured to be releasably attached to the distal end of the arm.

In yet another embodiment the robotic surgical system included a processor, at least one encoder to determine the location of at least one motor drive joint, a receiver for receiving electrical signals transmitted from the stapling unit and controlling its motion.

An exemplary disposable loading unit for use with a robot is disclosed U.S. Pat. No. 6,231,565 to Tovey et al. An exemplary surgical robot with proportional surgeon control is disclosed in U.S. Pat. No. 5,624,398 to Smith et al.

Another aspect of the present invention the robotic system has a frame, a robotic arm which is movable relative to the frame and has a stapling assembly with an elongated tube connecting the stapling assembly to the robotic arm. Both the elongated tube with the stapling assembly and the stapling assembly by itself are releasably attached and operatively coupled to the robotic arm.

One configuration of the stapling assembly can be removed and a different configuration attached and operated.

Regarding FIGS. **23** and **24**. The robotic system includes a coupling member that releasably attaches to the proximal end of closure tube **207** and radially couples to the proximal end of drive shaft **206**.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Preferably, the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

While this invention has been described as having exemplary designs, the present invention may be further modified within the spirit and scope of the disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

What is claimed is:

1. A surgical instrument, comprising:

a remotely controllable user interface;

a firing drive configured to generate a rotary firing motion upon a first actuation of said remotely controllable user interface and a rotary retraction motion upon another actuation of remotely controllable user interface;

a first drive member, wherein said remotely controllable user interface is selectively engageable with said first drive member; and

a second drive member, wherein said remotely controllable user interface is selectively engageable with said second drive member;

an elongate shaft assembly operably engaged with said first drive member and said second drive member; and

an end effector coupled to said elongate shaft assembly, said end effector comprising:

an elongate channel configured to operably support a staple cartridge therein;

an anvil movably coupled to said elongate channel; and

a cutting member operably supported within said elongate channel, wherein said cutting member is operably engaged with said elongate shaft assembly, wherein, when said remotely controllable user interface operates said first drive member, said first actuation advances said cutting member a first distance, wherein, when said remotely controllable user interface operates said second drive member, said other actuation retracts said cutting member a second distance, and wherein said second distance is greater than said first distance.

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